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Early Efforts to Grow Sugar Cane Seedlings in Hawaii

"In all of these experiments patience is required," said James E. Teschemaker, of Boston, in a letter he wrote the Royal Hawaiian Agricultural Society in 1852, urging that body to take steps toward producing sugar cane seedlings. He cautioned that disappointment must not be felt if initial efforts failed, and pleaded for perseverance in the work of "causing the sugar cane to bear seed." He held the idea that special manurial treatments would lessen the vegetative growth and result in the production of viable seed, and he outlined experiments which he advocated in this connection. He ended his letter by saying that the probability was great that through growing seedlings much better varieties could be obtained than those then cultivated.

The Royal Hawaiian Agricultural Society at their first annual meeting in 1851 had resolved, "That a committee be appointed to institute experiments with a view to obtain plants from the seed of sugar cane, and to procure information on the subject." (The committee appointed were E. P. Bond, chairman; D. Baldwin, G. A. Lathrop, B. Pitman.) Apparently this committee had addressed Mr. Teschemaker as one who could speak with authority on their problems.

At the annual meeting of June, 1853, Mr. Bond reported as follows:

As Chairman of the committee to obtain plants from the seed of the sugar cane, I regret to be compelled a second time to present an unsatisfactory report.

On Hawaii Mr. Pitman has been prevented from making any experiments to test the process suggested by Mr. Teschemaker, for obtaining germinating seed from the cane, he having been unable to find a suitable spot in his neighborhood in which to attempt them.

I subjoin a letter received from Mr. Pitman, from which it will be seen that he has little faith in the practical advantages which would follow success.

From Dr. Baldwin, of Maui, and Dr. Lathrop, of Oahu, the other members of the committee, I have received no report.

On Kauai, I have made some experiments, following as nearly as possible the directions of Mr. Teschemaker, but I am sorry to say that they have as yet met with no favorable result. Still the pursuit is an interesting one, and I do not yet despair of final success.

I am by no means sure that the varieties of cane which we have are the best possible for our soil and clime. The agriculture of the world may be enriched by the introduction of new varieties of the cane.

This is a subject well worthy of the continued attention of the Royal Hawaiian Agricultural Society.

In the following year lack of success was again reported.

It is of great interest to learn of these early attempts at sugar cane seedling production in Hawaii, made as they were some thirty-five years before Soltwedel in Java in 1888, and Harrison and Bovell in Barbados in 1899, demonstrated the practicability of producing new varieties of cane from seed.

That there was actually earlier proof of the fertility of cane seed is shown by Noel Deerr in *Cane Sugar,* who says:

The fertility of the cane was definitely established in May of 1858,* when an overseer at the Highlands Plantation in Barbados saw and recognized seedling canes growing in the field. He reported their presence to Mr. J. W. Parris, the proprietor, who grew these self-sown seedlings to maturity, and afterwards grew four and a half acres of seedling canes. This discovery was put on record in the Barbados Liberal of February 12th, 1859, and was confirmed shortly afterwards by several local planters. The question was followed up by Drumm in Barbados, who experimented in hybridization, and devised the method of ''bagging'', the inflorescence referred to later. It does not appear certain that Drumm ever obtained hybrids, though his communications on the matter in the local Barbados press obtained wide publicity in the Sugar Cane, the Produce Markets Review, and in Australia.

In 1862 self-sown seedlings were also observed in Java; in 1871 these were obtained of intent by Le Merle in Reunion, and about the same time the Baron da Villa Franca wrote as if the fertility of the cane was a matter of common knowledge in Brazil. All these observations, however, were forgotten, and systematic research work dates from the re-discovery by Soltwedel in Java in 1888 and by Harrison and Bovell in Barbados in 1889.

Long previous to this, however, it is possible that seedling selection had been practised by primitive peoples, and it is almost certain that it was as seedlings that some of the cultivated varieties of cane were originally segregated by some intelligent and observant savage. Mr. Muir has told the writer that he saw, during his travels in search of a parasite for the Hawaiian beetle borer, such a process obtaining amongst the New Guinea natives. A seedling cane, or any newly introduced sexual variant, is then in no wise different from any of the older varieties, the sexual origin of which has been forgotten.

Yield of Sugar in the Territory of Hawaii for Crop of 1923

	Acres	Tons Sugar Harvested	Lbs. Sugar per Acre	Tons Sugar per Acre
Total yield	114,286.16	530,957.64255	9,292	4.646
Irrigated Plantations	60,280.87	342,451.10055	11,362	5.681
Unirrigated Plantations	54,005.29	188,506.54200	6,982	3.491
Hawaii	53,055.29	186,085.0735	7,014	3.507
Oahu	22,377.58	138,472.0408	12,376	6.188
Kauai	21,470.07	94,780.8035	8,830	4.415
Maui	17,383.22	111,619.72475	12,842	6.421

* A statement in the ''Transactions of the Agricultural and Horticultural Society of India'' (1838, 2, 393), reads as if cane seedlings had even then been experimentally propagated in that country. In Ure's ''Dictionary of Arts and Manufactures'' of date c. 1845, the statement is also made that ''in India it grows to seed''. I have been unable to confirm or refute these statements.
N. D.

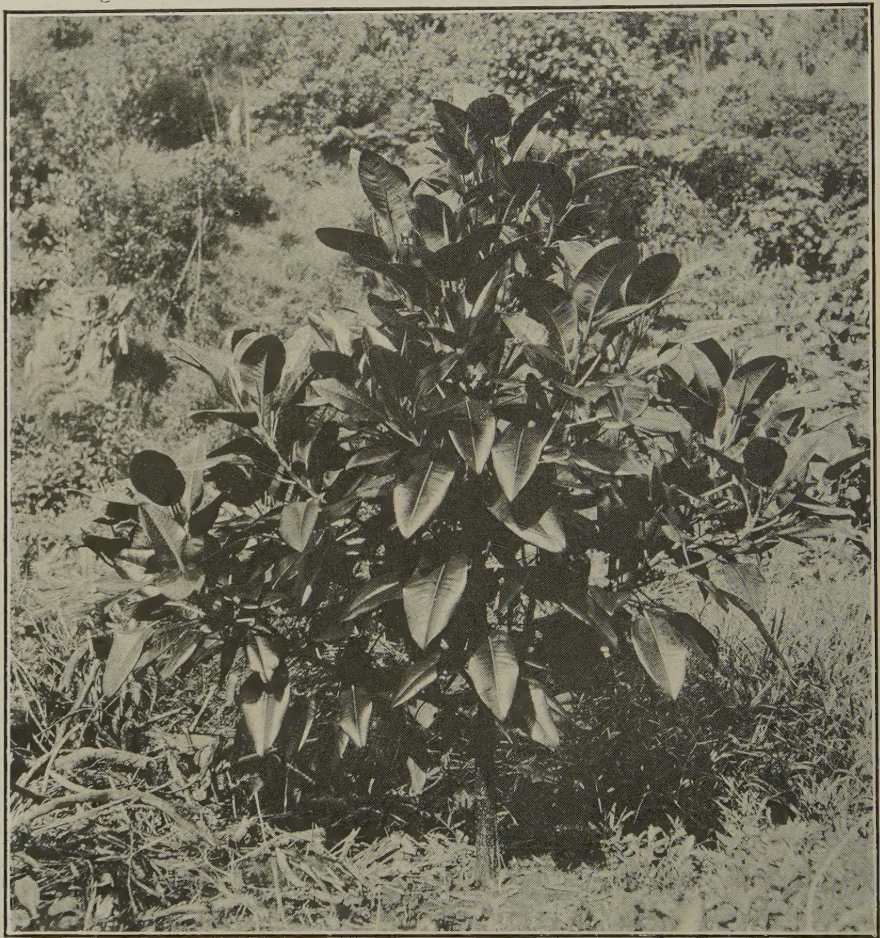
D 1135 at Pahala

D 1135 growing at Hawaiian Agricultural Company—2,100 feet elevation. On this plantation D 1135 seems to do remarkably well at this elevation, as can be seen by noting the large size of the stalks.

Remarkable Growth of Fig Trees in a Forest Planting

Three of the Australian figs are making such remarkable showings in forest plantings in various parts of these Islands that we can now safely conclude that they are going to become important components of our future forests.

The Moreton Bay fig is proving a favorite for planting as a shade tree in villages, about camps and near tanks and water troughs in pastures. Some remarkable specimens may now be seen in such situations at many points on Oahu,



Ficus macrophylla in forest planting in the lands of Helemano.

Molokai and Hawaii. These plants have in many cases, no doubt, received considerable care and attention to which their good appearance may in part be attributed. In none of these situations, however, has a plant of *F. macrophylla* made growth equal to that shown by some trees of this species planted out by Mr. McEldowney in the forest at about 1,100 feet elevation in the lands of Helemano

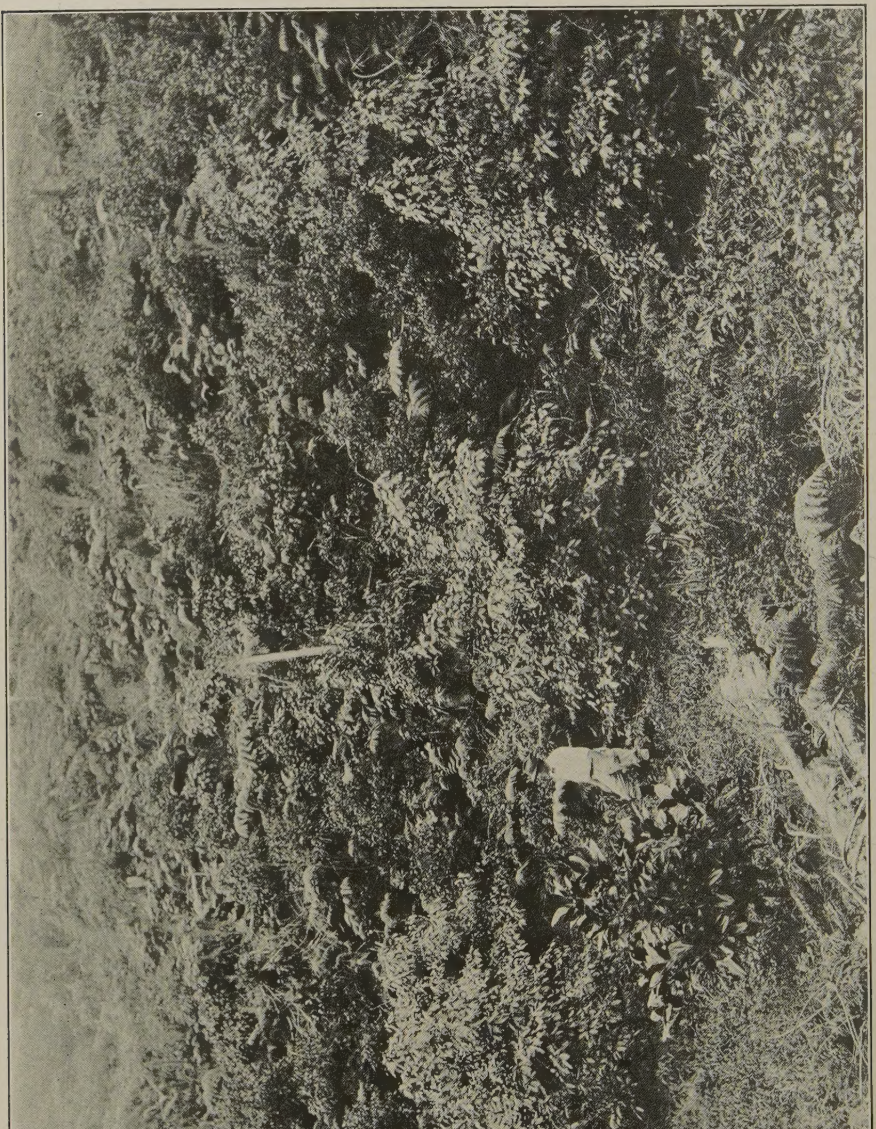
on Oahu. Seedlings 12 to 15 inches tall planted out in August, 1922, attained a height of 5 to 7 feet by December, 1923.

The Port Jackson fig, *Ficus rubiginosa,* is a close second to the Moreton Bay fig in numbers of trees being set out. From the results thus far obtained, it would seem that this tree is going to prove quite equal, if not superior, to the Moreton Bay for forestry purposes in many districts: however, it is, as yet, too

Ficus rubiginosa. This specimen was a seedling twelve inches tall when planted out in August, 1922. The photograph was taken sixteen months later.

early to advance a final conclusion in this matter. In the forest planting in Helemano, the Port Jackson fig has made a showing comparable to that displayed by the Moreton Bay, as may be judged from the accompanying pictures.

While the two figs mentioned have made very remarkable growth, their performances are paled by the spectacular display of vigor exhibited by another Australian fig, *F. glomerata,* included in the same planting. This fig was not



The tree on Mr. McEldowney's left and the one towards which he is looking are specimens of *Ficus glomerata.* A third tree of this species is seen at the extreme right of the picture and nearly in line with the other two. The tree in front of Mr. McEldowney is the specimen of *F. macrophylla* shown in our first illustration.

represented by any specimens in Hawaii prior to our introduction and we did not gain a correct idea of the nature of the tree from the published descriptions. We were not expecting much of it and consequently its behavior under Hawaiian conditions has proven a most agreeable surprise. Seedlings 15 inches tall planted out in August, 1922, attained a height of 10 to 15 feet by December, 1923. The foliage of this tree is more open than that of the Moreton Bay and Port Jackson figs and it will, therefore, encourage a heavier undergrowth than will these closer-leaved forms. It drops its foliage for a very short period each year while the other two figs retain a heavy foliage at all times. Our trees of *F. glomerata* were grown from seed colleced by Mr. Pemberton in Northern Australia. Our stock of young trees was quite limited and quickly exhausted. We are striving to secure additional seed by correspondence, but, as yet, have achieved no success in this direction. It is extremely difficult to get seeds of wild figs collected in quantity by correspondents who know the trees well enough to detect the species from which seed is desired.

Ficus glomerata has a much wider geographical distribution than either the Moreton Bay or Port Jackson figs. The two last named trees are confined to Australia while *F. glomerata* ranges from the Himalayas in Northern India to Queensland in Australia. It is described in botanical works as a "middle sized or large tree". It is said to grow by choice "in ravines, on the banks of rivers and in damp places". We consider it one of the best "prospects" now under trial for planting in the wet regions where we wish to build a rain forest.

H. L. L.

Rat Control*

By C. E. Pemberton.

Rat control by the poison method on the plantation of the Honokaa Sugar Co. has now been in active operation for over a year. It has been a commercial success though there has been by no means an eradication of the rat. Rats are still present in fair numbers in spots and unless the application of poison is vigorously continued there will undoubtedly be a reversion to the old conditions in a short time. This fact is fully recognized on the plantation and the poison campaign will most likely be carried on even more intensively in the future. The probable improvement in the poison used, the greater quantity applied, and the ever increasing knowledge of the habits of the rat, during the growing season of the cane and during and immediately after the harvest, has resulted in an improved understanding of when to apply poison and where to place it.

The feeling that wholesale poisoning has checked the rats to such an extent that a worth-while saving in sugar has resulted and that a very large reduction

* Presented at the meeting of the Association of Hawaiian Sugar Technologists, October, 1923.

in the rat population has actually occurred, is based on a combination of circumstances. The most gratifying fact of all is the very considerable reduction in the amount of rat-damaged cane in the 1923 crop as compared with previous crops. The 1923 crop is finally off and it is now possible to tabulate data secured for both the 1922 and 1923 crops during the entire period of harvest both years. The difference in damage, though recognized as each field came off this year, is strongly indicated in comparing the results of percentage counts made in each field for both crops as shown in Tables 1 and 2. Table 2, giving percentages obtained by Honokaa Sugar Company in 1922, shows an average rat damage to the cane for that year of 19 per cent. This crop had not been poisoned excepting in spots in preliminary experiments. Table 1, showing counts made by the writer in each field of the 1923 crop, gives an average damage for all of the fields of 4.29 per cent, ranging from no injury in some fields to 11.7 per cent where the worst injury occurred. This average was computed from an examination of 404,100 sticks of cane, taken in all sections of each field as it was harvested, and should fall close to the actual damage that occurred. Thus the unpoisoned 1922 crop was found by Honokaa Sugar Company to be rat damaged to the extent of 19 per cent while the poisoned 1923 crop was only injured to the amount of 4.29 per cent. This justifies the continuance of the poison method of control.

Apart from these data there is the strong testimony of every individual living about the plantation, respecting the general scarcity of rats about houses and in the fields, as compared with former years. The statements of the skilled field overseers should be recognized. Without exception they have repeatedly remarked on the almost complete absence of rats appearing from beneath the piles of cane along the flumes during the harvesting season. Very few rats have been so observed this year, and in many fields none at all. Last year, and in previous years, they are said to have been always very numerous beneath cut cane which had been left piled up overnight along the flumes. At the commencement of laboratory investigations of the rat in 1922, live rats for experimental purposes were readily obtained in quantity while the cane was being flumed. By the beginning of 1923 they were not so common and as months went by it became increasingly difficult to secure live rats, while during the past four months it has not been possible to secure any in this manner, though single individuals have been occasionally seen, and from 15 to 30 a day are usually caught in several hundred steel snap-traps operated daily.

Many individual cases could be cited of rat scarcity this year in fields notoriously infested during the past, and many interesting statements from even disinterested parties regarding comparisons of present with past conditions could be given. It will be sufficient here to cite one instance. In 1921, a certain slope in Field 29 (mature cane) was fenced in with galvanized iron sheets to the extent of about 1½ acres. This cane was then fired, cut and piled up within the enclosure. The following morning the cane was flumed and a total of 132 rats that ran out from beneath this cane were killed. This year, the same field was again harvested and not a single rat was seen under any of the piled up cane as it was flumed either at this particular spot or in any part of the whole field.

Rat burrows within the cane fields and on adjacent land are comparatively scarce this year. In 1922, it was an easy matter to locate a dozen or more in close proximity in any rat-infested field. Burrows can be found at present, but only after considerable search in most fields.

Without referring in further detail to the proof of beneficial results in the rat-poison campaign at Honokaa, we can reasonably assume that the results in 1923 have come from the persistent and intelligent application of poison. Rats are secretive in their habits, exhibiting great variation in choice of residence and food and are sometimes known to be strongly migratory under unknown causes. In spite of this, however, it would indeed be a most remarkable coincidence if the greatly reduced evidence of their presence and the positive reduction in their injury to cane at Honokaa were induced by causes other than wholesale poisoning.

We have always been confronted with the difficulty of finding dead rats. Where poison has been placed in quantity in fields known to harbor a large rat population, dead rats in reasonable proportion to the quantity of poison observed to be taken, are not found. Some dead rats and many dead mice are frequently seen, but not as many as would naturally be expected. What becomes of the poisoned rats has been somewhat of a problem. Exhaustive laboratory experiments with live rats have conclusively shown that the poison-baits when eaten do actually kill the average rat, and it is a fact beyond dispute that rodents in the field do eat the poison even more readily and in greater quantity than when confined in cages. Some definite observations in the field have been made to explain this in part. The mongoose, which is quite common in Hamakua, will eat dead rodents, either poisoned or trapped. Laboratory experiments show that the consumed poisoned rodents have no injurious effect upon the mongoose, where the rats or mice have died from eating strychnine or barium-carbonate. Poisoned rodents have been placed in the cane and frequently missed in 24 hours. Mongoose excrement filled with rodent hair is a common occurrence in the Honokaa cane fields. This, then, partly accounts for the disappearance of many rats that die in the open before getting away to their burrows. In the cane fields the field rat and mouse live in burrows in the ground. The rat burrows often extend to several feet in depth and frequently ramify into intricate branching galleries for from one to three yards in distance. This enables a poisoned rat to get away and die underground completely hidden from view. In the early stages of the poison campaign in 1922, when rats were very numerous, poisoned fields often smelled of decaying flesh, without otherwise showing evidences of dead rats. This may perhaps account for the scarcity of dead rats when fields were poisoned. It should be stated, however, that some of these burrows have been dug out without finding dead rats. As barium-carbonate has been the base in most of the baits used, the rat has had full time to hide after eating it, for this poison usually takes from 6 hours to 3 or 4 days to kill after being eaten. Where strychnine has been used dead rodents have been more frequently observed. This acts quickly after being taken, and rats and mice, particularly the latter, usually do not get far from the bait after taking part of it.

After testing numerous poisons at Honokaa, barium-carbonate and strychnine have been found to be the most practicable. The results have mostly been

obtained with barium-carbonate. As noted in Table 3, there has been only one large application of strychnine. This was in December, 1922. Most of the results on the 1923 crop had already been accomplished with barium-carbonate by the time this strychnine was applied. Both are splendid poisons for rats and mice, if intelligently and generously used. Barium-carbonate, a fine white powder, has been applied mostly in combination with wheat middlings in a proportion of one part barium-carbonate to three parts middlings. This is thoroughly mixed, moistened, kneaded to a heavy dough, rolled into sheets, cut into small flat circular cakes one-half inch in diameter, dried until hard and coated with paraffin to prevent mould development and general deterioration. This mixture has also been applied to some extent in the powdered, dry, uncaked condition. It is then put out in 4-gram paper packages or torpedoes, the paper being paraffined. The bulk of the poison applied on the 1923 crop, however, was in the form of the barium-carbonate paraffine-coated cake.

The strychnine has been used as a coating on whole wheat, using one ounce of strychnine (alkaloid) to 25 pounds of grain. The strychnine (alkaloid) comes finely powdered. It is first mixed with water, starch, and sometimes saccharine, salt and baking soda, into a heavy, creamy liquid and then poured over the wheat. This is then thoroughly mixed until the wheat is all wet. The grain is then dried and ready for use. Strychnine-wheat has been put out, with good results, in paraffin paper torpedoes using from ¼ to 1 ounce of grain per bait. It is readily taken by both rats and mice. Strychnine, so used, though a good poison for the average rodent, does not always kill. It either varies in toxicity, as purchased, or rats are resistant to it in widely varying degrees. A good many rats, in captivity, have been fed strychnine-wheat in quantity, without visible discomfort, while others, often large and vigorous, have been quickly killed on small amounts, not exceeding ½ ounce. Barium-carbonate, however, seems fatal to all rats. Both strychnine-wheat and barium-carbonate baits are quickly fatal to mice. Rats are slower to die. Mice have been killed repeatedly with one-half dozen grains of strychnine-wheat. Sometimes as few as 2 grains have proven fatal. Two or three grains of rolled oats dusted with barium-carbonate will generally kill a mouse. Some rats have eaten as much as 6 ounces of strychnine-wheat without fatal results while others die in a few hours after taking ½ ounce of it. Usually a few grains, in weight, of the barium-carbonate baits, proves fatal to rats.

Of late, barium-carbonate has been tested in the laboratory mixed dry with rolled grain and fed to rats in this form. Rolled oats treated in this manner has given splendid results. Being simply the dry, loose, rolled grain, dusted with barium-carbonate, using one part barium-carbonate to four parts grain, it seems to be a more natural rodent food than the more complicated mixtures. Rats take it well. This is really the big point in rodent poison work. Plenty of known poisons are available that will kill, but the biggest problem is to make it palatable or as nearly natural in attractiveness as possible. The barium-carbonate dusted rolled grain, in dry form, being cheap, easily mixed and safely stored without deterioration, may in time supplant the more complicated cake formula or strychnine-wheat form of poison at Honokaa. Field tests during 1924 will

prove its usefulness. It requires no heating, cooking or drying. The poison, being of a fine powdery nature, clings beautifully to the rough rolled grain, particularly rolled oats. When wrapped in 4-gram, paraffined paper torpedoes it makes a very satisfactory, cheap and easily distributed bait. Rats frequently carry away these paper packages. They are often missed in the field the day following application. In one case such a package was found within a rat's nest in the top of a Pandanus tree, the contents of the package being consumed and the nest vacated.

Other poisons have been tested in the laboratory with varying results. These included extract of squills, phosphorus, rat-typhoid virus in three forms, arsenic and cyanide of potassium. They all seem to have disadvantages over barium-carbonate or strychnine. Some gave no results of value. Phosphorus combined with wheat middlings and made into a cake gave fair results, but its odor, inflammable nature, expense and deteriorating qualities after mixing, are against it.

Barium-carbonate and strychnine have been used as rodent poisons for many years in various parts of the world and in most places are recommended. The U. S. Bureau of Biological Survey, in a recent publication, strongly favors barium-carbonate. The novel idea at Honokaa in the application of these poisons, is the scheme of waterproofing, whereby the cake-bait is paraffin-coated and the loose, dry baits wrapped in paraffined paper. This has been a great help when large quantities of the poison are mixed at one time and stored for future use, and it also tends to keep the poison fresh after being placed in the field.

Barium-carbonate costs from $65.00 to $70.00 per ton, and strychnine in the alkaloid form costs about $1.10 per ounce. At these rates it has cost the Honokaa Sugar Company about $60.00 per ton more to manufacture strychnine-wheat than barium-carbonate baits. Both costs are a great deal under the market quotations on commercial rat poisons manufactured by various firms in the States. Poisons manufactured at home also have the advantage of being fresh. There is nothing complex in their preparation. Strychnine-wheat, if made from the alkaloid, which is the best form, is liable to deteriorate rapidly if handled much or if reached by ants, weevils or other insects. The strychnine is present simply as minute crystals clinging to the surface of the grain. If these become disturbed much by insects, etc., they may be easily separated from the grain and much of the bait becomes worthless. For these reasons strychnine-wheat should be best if made on the plantations and used immediately. A careful supervision over the preparation of these simple mixtures is all that is necessary.

The good results in rat control at Honokaa Sugar Company have been obtained through constant and skilled attention in the manufacture of every pound of poison, and the large application of this poison three or more times a year in every part of the entire plantation, which comprises not only the cane but every gulch, rock pile, building, ditch, roadside and grassy or waste area. The aim has been to place about one set of poison every 10 or 15 feet. Most of the cane fields of the 1923 crop received only three applications, but, as shown in Table 3, some were covered four times and a few received a fifth treatment. The first application is given after the cane is well up and sufficiently advanced to show sticks bearing considerable sugar. It is then that the rats appear to move into the fields. It has also been found important to apply poison in waste areas,

gulches, rock piles, roadsides, ditches, etc., adjacent to cane fields immediately after the cane is harvested. The rats which were housed in their burrows within the standing cane, move out of the fields as soon as the cane is cut. Their food and cover is gone. Proof of this has been positively established in various ways. These moving, hungry rats, first accumulate in the lands adjacent to the cut fields. The denser the vegetation in these adjacent areas the more suitable it is for the rats and the longer they are liable to remain. If it is in cane they will naturally concentrate there, but even rough, sparsely overgrown areas will harbor many of these migrating rats for some weeks at least. It has been found that trapping in such places immediately following harvest, will yield rats in greater quantity for a time than would be the case in the cane before it was cut, and also that poison placed in such localities is taken to a considerable extent.

The total cost at Honokaa Sugar Company to manufacture and apply the poison, together with the constant operation of several hundred traps daily, amounted to about $5,000 for the past year. Prior to 1922, the cost per year of trapping alone ran from $5,000 to $7,000 with no visible results. During the years 1914 to 1922 Honokaa Sugar Company and Pacific Sugar Mill trapped a total of 1,138,011 rats; actually tons of rats, yet no real return for the money could be noted. This huge total only represented a very small portion of the rat population in the community, for these traps could only cover a small fraction of about 14,000 acres constituting the two places. The aim in the poison campaign, however, has been to cover every acre of this area not once, but, as above stated, three or more times per year. As the annual progeny of a single pair of rats in a tropic or semi-tropic region can be as high as 800, in the absence of famine, floods and natural enemies, we can expect the progeny to be large under Hamakua conditions where rats seem to thrive, and any control by poisoning can only hope to be successful by poisoning several times a year rather than once. With an average gestation period of 21 days, and reproduction possible at the age of three months, an average of six litters per year and an average of eight young per litter, we have a pest to deal with that is enormously prolific and whose increase to positive swarms in our cane fields is only prevented by a scarcity in proteid foods and by complex minor causes of which we know nothing. One killing a year, then, is greatly insufficient.

The actual loss in sugar in cane fields where rats are numerous is surprisingly greater than is generally supposed. The loss not only lies in the particular joints of the stick which have been eaten into, but a general deterioration usually occurs in the whole stick and the nearer the eaten joints the more affected the juice becomes. During August and September, 1923, samples of rat-eaten and sound canes were taken from cane fields at Honokaa and submitted to Mr. A. Fries, Chemist of Honokaa Sugar Company and Pacific Sugar Mill, for comparative analyses. Eighteen separate lots were cut, in as many days, and separate analyses were made of the sound and rat-eaten lots each day. In every case entire sticks were cut and the total extracted juice was used. Only slightly damaged cane was selected for the tests, usually bearing only from one to three injured joints, and only live, growing, 15 months old cane was cut. The results, as given in Table 4, are very interesting. The average from the eighteen lots showed that in the sound canes the yield of commercial sugar per ton of cane

amounted to 230.3 pounds of sugar, as against 195.8 pounds or 14.9 per cent, in the rat damaged lots, or 8.77 tons of cane to the ton of sugar in the sound lots and 10.41 tons of cane to the ton of sugar in the injured lots. As stated above, these data were secured from cane only slightly rat-damaged. The sugar loss in average damaged cane will be greater. As already stated, the rat-damage at Honokaa in the 1923 crop amounted to 4.29 per cent. If this 4.29 per cent were only slightly damaged as in the eighteen samples, there would be a 14.9 per cent sugar loss in 4.29 per cent of the total crop. Actually, it has been greater than this even under the present control. As computed by Mr. Haldeen, former chemist at Honokaa Sugar Company, when rats were out of control on this plantation, the damage was generally so great that rat-eaten sticks showed about a 50 per cent sugar loss. Assuming the fields, then, to show about 25 per cent of the sticks injured, or even 19 per cent as in 1922, a 50 per cent sugar loss in the sticks injured would bring an actual loss in the whole crop of from 10 to 12 per cent of the potential available sugar. In the poisoned 1923 crop this falls to about 1 per cent, which indicates that rat control by poisoning has been worth while, if only these data are considered.

A difference of 10 per cent in sugar yield at Honokaa Sugar Company this year at 7-cent sugar amounts to from $75,000 to $80,000. In other words, I believe, and they believe, that there has been some $70,000 to $80,000 worth of sugar added to their bags through rat poisoning.

Apart from the deterioration in the juice in rat-eaten cane that comes to the mill, there has also been a total loss in much cane that is killed outright in the fields through heavy rat damage. This cane never reaches the mill, but is left dead on the field. The heavier the rat damage in any field the more dead cane is seen lying about after the harvest. This dead cane is caused by rats eating clear through the stick, usually near the base and a good deal of cane eaten partially through becomes broken off by the wind. A few estimates have been made of the amount of such dead cane lying in fields after harvest where rat damage had been heavy in the 1922 crop. By measuring the length of all the dead sticks lying in a given area showing average damage for the field, and assuming a certain average weight per foot of cane, a fairly close estimate could be made. Two fields were taken in 1922 which showed from 25 to 50 per cent rat damage in the live cane at the time of harvest. In one case it was found that about 11⅓ tons per acre of dead cane remained in the field and in the other 38 tons per acre or above half the cane produced in this area.

Lastly, an important result in any rat campaign in Hamakua is the possibility that extensive reduction of rats will materially check the danger of bubonic plague infection among the inhabitants of the district. It is not expected that this disease will be stamped out nor is there any hope of entirely eliminating the rats, but unquestionably the fewer the rats, the less chances there are for human plague cases. This being primarily a rat disease, carried or disseminated so far as we know almost solely from rat to man by the rat flea, one of the largest factors in preventing its spread lies in greatly reducing the rat and coincidentally its flea. Control of the rat about the villages and camps only cannot help much, owing to their great migratory ability, which enables them to move into villages and camps overnight. Unfortunately, the very species of rat flea which is associated with the most plague-infected regions in India, is the same species commonly occurring on rats in Hamakua. Other regions in India where

rats bear other species of fleas, but rarely this particular one, are said to be comparatively free of plague. Recent medical research in India has brought this point to light. This particular flea seems especially adapted for successfully transmitting plague from rat to man and in some way has reached Hawaii at an unknown date.

There has been one death from plague at Honokaa this year, the only one for the district in 1923, as against twelve in 1922, six of which occurred at Honokaa. The death this year was of the pneumonic type, which is plague in its worst form. Plague in Hamakua is fatal. In other countries it is not always fatal.

It is hoped that the demonstration in rat control by poisoning, that has been in operation at Honokaa during the past year and which is actively going on at present, will in time show such striking results that control will be undertaken along similar lines over all of Hamakua, and that such control, in cooperation with the Territorial Board of Health, whose activities relate to the determination of areas of plague infection, their disinfection, and the improvement of camp and village sanitation and structure to guard against plague entrance to dwellings, etc., will ultimately reduce the danger of human plague infection to a low minimum. There are grounds for such a hope.

TABLE I.

RAT DAMAGE TO CANE HONOKAA SUGAR COMPANY CROP 1923—POISONED.

Field	No. Sticks Examined	Per Cent Rat-Damaged
20	6,000	.96
30	22,000	6.20
38	20,500	10.60
13	8,000	.69
33a	6,000	2.60
18	25,000	1.74
1	4,000	1.47
1a	7,000	.90
37	8,000	5.60
26	36,000	5.20
34	20,000	8.90
36	22,600	11.70
12	11,000	2.30
7	11,000	.90
D	4,000	.00
29	25,000	9.60
25	25,000	6.00
6	12,000	.36
11	9,000	8.80
24	3,000	.00
5	6,000	1.90
17	7,000	.89
28	35,000	3.85
10	8,000	7.40
22	14,000	8.45
35	12,000	4.30
19	2,000	5.90
33	35,000	3.10
Total	404,100	Average 4.29

TABLE II.

RAT DAMAGE TO CANE HONOKAA SUGAR COMPANY CROP 1922—UNPOISONED.

Field	No. Sticks Examined	Per Cent Rat-Damaged
2	3,700	25.00
33	4,700	16.00
37B	1,000	23.50
Chow Choy Cont.	1,100	26.50
1	2,600	16.50
21	1,400	12.30
17	600	11.00
19	1,400	19.00
24	1,200	21.00
28	700	16.00
27	5,700	22.00
Total	24,100	Average 18.90

TABLE III.

RAT POISON APPLICATION HONOKAA SUGAR COMPANY CROP 1923.

Field	First Appl.	Poison Used	2nd Appl.	Poison Used	3rd Appl.	Poison Used	4th Appl.	Poison Used	5th Appl.	Poison Used
1a	6-17-22	Barium-carb. Cake	11- 7-22	Barium-carb. Cake	12-20-22	Strychnine Wheat		Barium-carb. Cake		
5	5-22-22	"	11-11-22	"	12-21-22	"	2-22-23	"		
6	7-19-22	"	11- 9-22	"	12-21-22	"				
7	7-31-22	"	11- 8-22	"	12-22-22	"				
10	7-18-22	"	10-25-22	"	12-28-22	"	5-14-23	"		
11	7-19-22	"	10-30-22	"	12-22-22	"	5-12-23	"		
12	7-22-22	"	11- 4-22	"	12-23-22	"				
13	7-26-22	"	11- 6-22	"	12-24-22	"				
17	5-31-22	"	11- 2-22	"	12-20-22	"	5- 7-23	"		
18	5-25-22	"	10-30-22	"	12-19-22	"				
20	5-20-22	"	10-24-22	"	12-21-22	"				
25	6-15-22	"	10-20-22	"	12-27-22	"	4-30-23	"		
26	6-17-22	"	10-21-22	"	12-22-22	"	5-15-23	" and Flour		
28	6-26-22	"	10-23-22	"	12-24-22	"	4-18-23	Barium-carb. Cake	7-30-23	Barium-carb. Cake
29	6-30-22	"	10-19-22	"	12-27-22	"	2-11-23	Strychnine Wheat	7-30-23	"
30	7-12-22	"	10-13-22	"	12-22-22	"	6-25-23	"		
33a	5-29-22	"	10-23-22	"	12-19-22	"				
34	3-22-22	"	10-10-22	Strychnine Wheat	12- 8-22	"				
36	6-14-22	"	10-16-22	Barium-carb. Cake	12-30-22	"				
37	6-30-22	"	10- 4-22	"	12-22-22	"				
38	7- 8-22	"	9-30-22	"	12-18-22	"	3-28-23	"	6-22-23	"

Table IV.

ANALYSES OF RAT EATEN AND SOUND CANE.

Polarization in Cane Calculated from Analyses and Weights of Bagasse and Juice. Juice expressed by Laboratory Hand Mill.

Date		Brix	Juice Pol.	Purity	Cane % Pol.	Yield of Comm. Sugar per Ton Cane (Pounds)	Tons Cane per Ton Sugar
August 20	R	16.53	14.00	84.7	11.68	203.2	9.84
	S	17.61	15.18	86.2	12.80	226.6	8.83
" 21	R	14.76	11.89	80.6	9.97	166.4	12.02
	S	17.70	15.63	88.3	12.99	234.8	8.52
" 22	R	18.00	15.64	86.9	13.36	238.0	8.40
	S	17.78	15.78	88.7	13.39	242.4	8.25
" 23	R	15.00	12.19	81.3	10.36	173.6	11.52
	S	16.00	13.71	85.7	11.65	205.2	9.75
" 30	R	17.10	14.68	85.9	12.14	213.0	9.34
	S	18.40	16.71	90.8	13.79	255.2	7.84
Sept. 1	R	16.42	13.51	82.3	11.26	190.8	10.48
	S	16.52	14.36	86.9	11.92	212.4	9.42
" 4	R	15.03	12.04	80.1	9.93	163.4	12.24
	S	16.81	14.69	87.4	12.19	218.2	9.17
" 4	R	13.95	10.90	78.1	9.28	149.0	13.43
	S	15.60	13.20	84.6	11.13	193.4	10.34
" 6	R	16.95	14.61	86.2	12.11	214.0	9.35
	S	18.84	16.96	90.0	14.22	261.0	7.66
" 6	R	14.10	11.13	78.9	9.41	152.8	13.09
	S	16.30	14.07	86.3	11.72	205.4	9.74
" 7	R	16.51	13.78	83.5	11.58	199.0	10.06
	S	17.16	14.89	86.8	12.39	220.6	9.07
" 13	R	16.50	14.06	85.2	11.77	206.0	9.71
	S	16.70	14.43	86.4	12.00	212.6	9.41
" 14	R	15.00	12.53	83.5	10.40	178.6	11.20
	S	19.10	17.13	89.7	14.28	261.4	7.65
" 15	R	16.13	13.88	86.1	11.71	206.0	9.71
	S	18.60	16.99	91.3	14.17	262.4	7.62
" 17	R	18.60	16.25	87.4	13.57	242.8	8.24
	S	17.45	15.46	88.6	12.96	234.8	8.52
" 18	R	16.45	13.66	83.0	11.25	192.2	10.40
	S	19.43	17.80	91.6	14.62	269.2	7.43
" 19	R	17.31	14.73	85.1	12.08	211.2	9.47
	S	16.80	14.74	87.7	12.38	222.0	9.01
" 20	R	17.32	15.23	87.9	12.48	224.4	8.91
	S	16.03	13.98	87.2	11.61	207.8	9.62
AVERAGES							
Rat Eaten		16.23	13.59	83.73	11.35	195.8	10.41
Sound		17.38	15.32	88.15	12.79	230.3	8.77

The History of the Sugar Cane Variety H 109*

(Compiled from the publications and files of the Experiment Station by H. P. Agee.)

1904

No sugar cane seedlings were propagated in Hawaii before 1904. In that year Charles F. Eckart, then Director of the Experiment Station of the Hawaiian Sugar Planters' Association, obtained 279 seedling plants. These germinated almost entirely from seed imported from the West Indies. None of these seedlings from the sowings of 1904 finally attained commercial significance.

1905

The Hawaiian Planters' Monthly of January 15, 1906, gave an editorial account of the work of 1905. In part it read:

> The Experiment Station has this season attained remarkable results in the propagation of canes from seed. At the present time there are upwards of five thousand young plants, in various stages of growth, many of which are far enough advanced to plant out in the field. The results are all the more gratifying, because these plants all germinated from seed gathered at the Station from this season's tassels; whereas, in the experiments conducted last year, all of the plants that survived were from imported seed.

1906

The Annual Report of the Division of Agriculture and Chemistry of the Experiment Station for the year ending September 30, 1906, said:

> During the tasseling period of 1905, the Division repeated its efforts of the previous season in the endeavor to produce seedlings from Hawaiian grown seed. Between the dates of December 6 and December 28, 1905, 5,608 seeds germinated in the propagation boxes, yielding 5,134 plants for setting out in the Experiment Station field.
>
> Following the experience of the Division during the tasseling season of 1904, the success attending the germination of Hawaiian grown seeds in 1905 surpassed our expectations. This difference between the results of the two periods may be attributed to the following causes:
>
> 1. During the time the canes were in flower in 1904, high winds and excessively wet weather prevailed, the majority of the tassels being blown to pieces before the flowers were sufficiently matured to permit pollination and the formation of seeds. These conditions did not obtain to any serious extent in the winter of 1905.
>
> 2. In 1904 only a small number of canes other than Lahaina were in tassel simultaneously with the latter variety. The chances of cross-fertilization were therefore correspondingly small. In the winter of 1905 a large area of varieties, about forty in all, situated immediately to windward and bordering on a Lahaina field, were in flower.

* Originally published in the Honolulu Advertiser of September 16, 1923.

A very interesting observation with respect to the influence of adjacent varieties on the fertility of Lahaina seeds was permitted during the last season. In the Station fields there were two different areas under Lahaina cane, one being directly to leeward of the forty varieties mentioned, during the prevailing northeast trades, and the other to leeward of the same varieties only during the spasmodic northwesterly winds. From the former area under Lahaina 471 fertile seeds were obtained, and from the latter area only 60, notwithstanding that a greater number of tassels were taken from this particular locality than from the other . . . . .

In addition to the seedlings enumerated above, 98 plants from unknown parents were planted in the field, making a total for the season's work of 5,232 seedling canes. . . .

1907

The Annual Report of the Station for the year 1907 said:

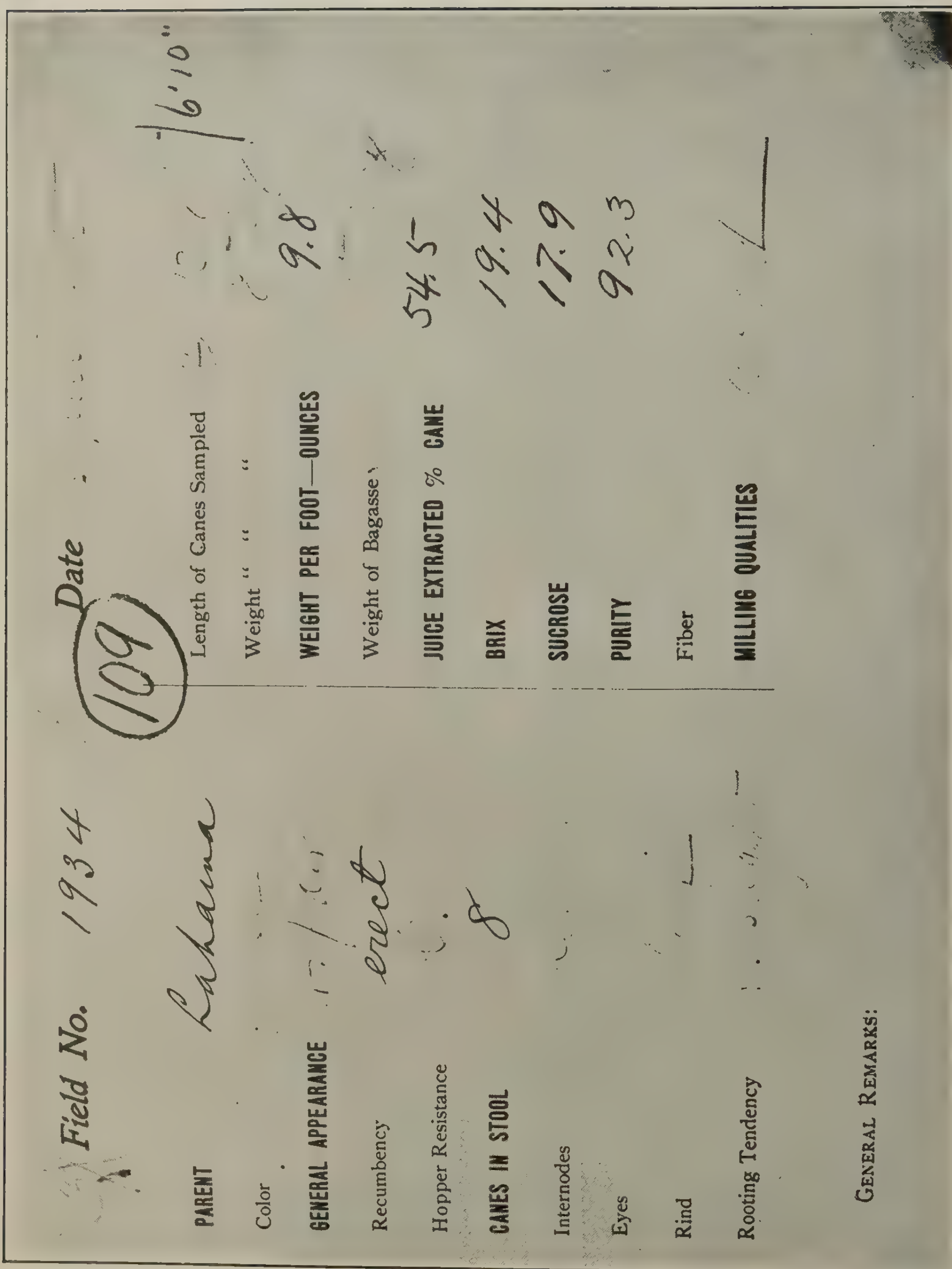
The large quantity of seedlings, 5,232 in number, which was originally set out has been reduced to 355, the total number representing those varieties which have shown up especially well.

The report of the Division of Agriculture and Chemistry said:

Following the first selection of seedlings from the sowings of December, 1905, it was found that a larger number than was expected would have to be retained for further trial, and to avoid the necessity of adding to the field area of the Experiment Station as would be required if they were to pass through the plat stage before being shipped to the plantations, the Division decided to modify the original plans with respect to their distribution. Accordingly, one cutting from each of at least fifteen seedlings was sent to each plantation in the Association to form the nuclei of cane nurseries. These consignments are to be followed by additional shipments of other varieties during the next planting season, and by 1909 it is expected that several hundred varieties will be growing in the nurseries of each plantation, and material will be at hand for subsequent careful tests into the relative suitability of the different varieties in their separate environments.

In April of 1907, a record was made of the appearance and general characteristics of each of the five thousand and more seedlings grown the previous year from the sowings of 1905. These canes bore the temporary numbers 280 to 5396, inclusive. Those canes which were to be reserved for further testing were given a permanent number; these ran from 1 to 333, omitting a few numbers which had previously been assigned to seedlings from the sowings of 1904. On April 16, 1907, the cane bearing the temporary number 1934 was marked "109" by Mr. Eckart, who had evidently given much personal attention to describing and selecting these canes, as the notes and figures designating the permanent numbers appear in his handwriting in a large record book which was used for this purpose.

The cane which thus became H 109 was a stool of eight stalks, a seedling of Lahaina. In general appearance it was "very fair"; in color, "rose". The sticks were "erect." The hopper resistance was "good"—internodes, "medium;" eyes, "medium;" rind, "hard;" rooting tendency, "very slight." A juice sample was obtained from two sticks; one of these was 13 feet 8 inches long, the other 6 feet 10 inches. The weight per foot of stick was 9.8 ounces. The juice resulting from a 54.5% extraction (juice on cane) had a brix of 19.4; sucrose, 17.9; purity, 92.3. The milling qualities were considered "good."



Field No. 1934 Date 109

PARENT	Lahaina	Length of Canes Sampled	6'10"
Color		Weight " "	
GENERAL APPEARANCE		WEIGHT PER FOOT—OUNCES	9.8
Recumbency	erect	Weight of Bagasse	
Hopper Resistance		JUICE EXTRACTED % CANE	54.5
CANES IN STOOL	8	BRIX	19.4
Internodes		SUCROSE	17.9
Eyes		PURITY	92.3
Rind		Fiber	
Rooting Tendency		MILLING QUALITIES	

GENERAL REMARKS:

Reproduction of a portion of page 223 of the original record book of the Experiment Station, H. S. P. A., on seedling canes: The Lahaina seedling bearing the temporary number 1934, on account of the qualifications covered by the notes of April 16, 1907, became H 109, when the number 109, shown here enclosed in a circle, was given to it by C. F. Eckart. The notes describing the seedling are in Mr. Eckart's handwriting.

In a marked copy of Circular 4, which consisted of a printed list of the notes from the large record book, again in Mr. Eckart's handwriting, we find H 109 marked to indicate that it was one of the canes to be set out in plats in June, 1908, in the main field of the Station, and further that it was among those varieties giving the greatest growth from cuttings at the age of three months. It is of interest to note that of more than five thousand seedling varieties observed that

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Hawaii No.	Parent.	Color.	Recumbency.	Hopper Resistance.	Canes in Stool.	Internodes.
~~107~~	~~Lahaina~~	yellow	moderate	good	4	medium
109	"	rose	none	"	8	"
~~110~~	~~"~~	yellow	"	"	15	"
111	"	"	moderate	"	9	"
~~113~~	~~"~~	"	"	v. fair	12	"
(L) ~~115~~	~~"~~	"	"	"	6	"
~~116~~	~~"~~	"	none	good	19	"
117	"	"	moderate	v. fair	10	"
~~118~~	~~"~~	"	"	"	12	"
119	"	"	"	"	15	"

30

Hawaii No.	Parent.	Color.	Recumbency.	Hopper Resistance.	Canes in Stool.	Internodes.
[illegible]	[illegible]		"	v. fair	7	"
(2) 394	Yellow Bamboo	"	"	good	6	"
(R) ~~395~~	~~White Mexican~~	"	"	"	10	"
396	Yellow Bamboo	"	none	"	13	"
~~397~~	~~" "~~	"	"	v. fair	9	"
* (A) (H) 398	Not known	"	moderate	good	7	"
C 399	White Mexican	yellowish, green	"	v. fair	10	r. long

A = Greatest growth from cuttings at age of 3 mos

B = Next to A in growth from cuttings at 3 mos.

C = " " 15 " " " " " " "

1 = Class of cane at time of selection of original stools from seed

2 = " " " " " " " " " " " "

H = [illegible]

R = [illegible]

□ = To be set out in plots in June, 1908 - Main fields

Reproduction of portions of pages 12 and 30 of a copy of Circular 4 of the Experiment Station, H. S. P. A., marked by C. F. Eckart. Of more than five thousand seedling varieties inspected in 1907, H 109 was one of thirteen which was marked both with a rectangle to show that it was to be set out in plots in 1908, and with "A" to show that it was among those that had made the greatest growth from cuttings at the age of three months.

year, only twenty were marked with the letter "A" denoting, "greatest growth from the cane at the age of three months." Only thirty-seven were marked with a rectangle to show that they were "to be set out in plats in June, 1908, main field."

Of all the canes under observation in 1907, only thirteen were designated on both scores described above. These canes were: H 220, H 61, H 72, H 109, H 119, H 149, H 151, H 165, H 226, H 270, H 280, H 311 and H 385.

These records can leave no doubt but that H 109 was recognized as a promising cane in 1907.

Small lots of cuttings from a number of the seedlings were sent to the plantations in 1907. The plantations which received a cutting of H 109 in 1907 were the Waialua Agricultural Company and Hawaiian Agricultural Company. Separate record books were kept at the Station for the varieties under trial at each plantation. Notes from the Waialua Agricultural Company show that the H 109 sent there in 1907 was planted at an elevation of 1,100 feet. On April 25, 1908, the growth resulting from this planting was denoted as "good" by the Station representative. On October 27, 1908, E. G. Clarke marked the growth as "fair" and later, March 31, 1910, the ratoons were observed to be "poor" by J. H. Wale. Mr. Clarke and Mr. Wale were then agriculturist, and assistant agriculturist of the Experiment Station.

E. Faxon Bishop in his address as President of the Hawaiian Sugar Planters' Association, in discussing the work of the Experiment Station said, "Mr. Eckart's Hawaiian seedlings alone cover a great work, and it puts him in a class to be envied by all who are identified with scientific agriculture."

The H 109 shipped to the Hawaiian Agricultural Company in 1907 was planted at an elevation of 2,000 feet. An undated note says, "good growth, color, green." A subsequent note by Mr. Wale, on September 4, 1908, reads, "very good, 21 large sticks." The records show that the planting at 2,000 feet elevation was duplicated at 1,100 feet; and here again we find an undated note saying, "good growth, color green, healthy," and a note dated September 5, 1908, by Mr. Wale reading, "good." The cane planted at 1,100 feet and 2,000 feet elevations was cut for seed and planted on January 11, 1909, in field "Lower Goodale," about 1,300 feet elevation.

1908

The Hawaiian varieties had in 1908 been reduced to the number of 185. The Annual Report for that year records this fact, together with the statement that shipments to plantations had been made in 1908 and that further shipments were to be made in 1909. The unpublished records show that H 109 was sent in 1908 to Kihei Sugar Company, Niulii Mill and Plantation Company, and to the Union Mill Company.

The cane growth resulting from this shipment to Kihei was inspected on October 5, 1908, for a note reads: "Very good, better than Lahaina." This cane was replanted in Field A at 300 feet elevation. It is significant to note that of twenty-two varieties inspected at that time, only two of them are marked "Very good, better than Lahaina."

On May 18, 1909, the growth of this H 109 planting was again inspected and a note made reading: "Very good (second best)."

The shipment that went to the Union Mill Company in 1908 was planted, according to the memorandum, in "Field below cattle pen, mixed with 1907 cuttings." On September 22, 1908, Mr. Wale found the growth of this H 109 "very good," and on March 17, 1909, another note, probably that of Mr. Clarke, reads: "*Very good,* (best)."

The shipment of seedlings that included H 109 went to Niulii Mill and Plantation Company from the Station on June 16, 1908. These were planted at an elevation of about 650 feet and on September 23 Mr. Wale found the growth "*good.*" A later note, uninitialed, probably Clarke's, shows the growth of this H 109 "*very good,* (one of the best)."

1909

Mr. Eckart, in the Annual Report of the Experiment Station for 1909, listed the varieties that were showing up well on the preliminary trials on the plantations. The list of fifty-two canes on Hawaii included H 109. The Maui list named H 109 among nineteen varieties. Previous to 1909, the seedling H 109 had not been distributed to Kauai, and the only plantation on Oahu that had received the seedling that was destined to become the principal variety of the island was the Waialua Agricultural Company.

In 1909, however, the variety H 109 was sent to the following plantations:

Oahu—
- Ewa Plantation Company
- Kahuku Plantation Company

Maui—
- Wailuku Sugar Company

Kauai—
- Kekaha Sugar Company, Ltd.
- Lihue Plantation Company, Ltd.

Hawaii—
- Halawa Plantation, Ltd.
- Honomu Sugar Company
- Laupahoehoe Sugar Company
- Olaa Sugar Company, Ltd.
- Union Mill Company

The cane resulting from the shipment that went to Ewa in 1909 was cut in 1910 and planted in Field 3A along with other seedlings and varieties that had been received from this Station in 1907 and 1908. These plantings in Field 3A were inspected on May 12, 1911, and a note by Wale reads, "very good." Only about six of the seedlings were so marked.

The Lihue planting of H 109 received in 1909 bears a note by Wale, April 11, 1910, "Good, equal to Yellow Caledonia."

In 1915, the Ewa Plantation Company reported over 1,071 acres of H 109 in their 1916 and 1917 crops. Oahu Sugar Company had 373 acres, and the Waialua Agricultural Company had 120 acres. A number of other plantations had begun to spread this cane. The early predictions in connection with the Hawaiian seedlings had come true. A cane of great commercial worth had been [illegible]. Photographed at the Experiment Station [illegible] Plate 1024.)

The shipment sent to Kekaha was planted in March in the manager's yard at 15 feet elevation, and on April 7, 1910, Wale found the resulting growth "Good."

Dr. H. L. Lyon, in a pathological report dated October 24, 1910, reported that H 109 appeared to him to be one of the four best canes of the Hawaiian seedlings. H 20 had produced the thickest sticks, while H 109 had produced the longest.

1910

Twenty-three plantations were sent cuttings of H 109 from the Station in Honolulu in 1910. A list of these plantations by islands follows:

Oahu—

Honolulu Plantation Company
Oahu Sugar Company
Waimanalo Sugar Company
Waianae Company

Maui—

Hawaiian Commercial & Sugar Company
Maui Agricultural Company, Ltd.
Pioneer Mill Company

Kauai—

Kilauea Sugar Plantation Company
Koloa Sugar Company
Waimea Sugar Mill Company

Hawaii—

Hamakua Mill Company
Hawaii Mill Company
Hawi Mill & Plantation Company
Honokaa Sugar Company
Hutchinson Sugar Plantation Company
Kaiwiki Sugar Company
Kukaiau Sugar Company
Onomea Sugar Company
Paauhau Sugar Plantation Company
Pacific Sugar Mill
Pepeekeo Sugar Company
Puako Sugar Company
Waiakea Mill Company

1911

In the Annual Report for 1911, Mr. Eckart published the results of the first plat experiments, giving weights and analyses of thirty-one Hawaiian seedlings.

H 109 gave over a hundred tons of cane and ranked eighth in the test, outyielding Yellow Caledonia and Lahaina by liberal margins.

In connection with information to be given later concerning the development of H 109 at Ewa, it should be recorded here that this was one of the seedlings that had attracted the attention of the late George F. Renton as early as 1910, for on February 17, 1911, he wrote the following letter to Mr. Eckart:

I have your letter of the 16th inst., in which you notify me of shipment of five boxes of cuttings, namely, H 27 and H 99, from the Station to the Ewa Plantation Company. I am exceedingly obliged for these.

If you can spare them during the harvesting, I would also like to get some cuttings from the following varieties:

H 109, H 167, H 227, H 69, H 269, H 199, H 291, H 349.

I would also like to get any other varieties you care to send. I merely mentioned the above because I made a note of them when I visited the Experiment Station December 15th, last.

1912

It was in 1912 that data from preliminary tests on plantations began to confirm the earlier observations showing H 109 to be among the leading seedlings that were competing with the established varieties. The Annual Report of the Station read:

The work of testing and extending the seedling varieties has progressed appreciably during the year, and there are some plantations with considerable area devoted to the new varieties.

The results of preliminary tests have in several instances been reported, and the canes giving the more favorable yields in each case are indicated in the following tabulation:

Locality	More Promising Seedling Varieties				
Aiea		H 109	H 333	.....	.....
Waimanalo	H 27	H 109	.....	.....	.....
Paia	H 27	.....	.....	H 240	.....
Wailuku		.....	H 333	D 1135	.....
Koloa		.....	H 333	.....	H 338
Kilauea	H 27	H 109	H 335	.....	.....
Onomea		.....	.....	H 20	.....

These preliminary tests seem to place special emphasis upon H 27, H 109 and H 333.

At Waimanalo, H 109 had produced seven tons of sugar against five from Rose Bamboo. The Hawaiian Planters' Record of August, 1912, contained a brief article on seedlings at Aiea. The data published through the courtesy of James Gibb, showed H 109, in a single row test, to have yielded the remarkable result of 114.4 tons of cane and 20.58 tons of sugar per acre. H 109 growing between Lahaina and H 41 had evidently encroached upon its competitors.

In the short ratoon variety comparisons at the Station field, H 20, D 1135, H 99, H 333 and H 109 gave yields definitely better than Yellow Caledonia and Lahaina.

An exceptionally large stool of H 109 from forced cropping. Grown at the Experiment Station, H. S. P. A., Makiki Plots (1924).

1913

In the latter part of 1913 the writer compiled an acreage census of cane varieties.* There were thirteen Hawaiian seedlings included in a tabulation which is here reproduced. These were the foremost ones in point of area:

	Acres Embraced in Crops of		
Variety	1913	1914	1915
H 20	12	128	5
H 33	1	1	13
H 109	...	26	62
H 146	20	39	63
H 181	...	1	10
H 197	...	20	18
H 202	1	1	10
H 227	...	12	119
H 291	...	25	15
H 333	...	4	60
H 335	8	....	18
H 338	...	33	30
Striped Mexican †	165	146	283

There were in all twenty-six Hawaiian seedlings which had been extended to areas of one acre or more. The report said:

> To these twenty-six Hawaiian seedlings the H. S. P. A. plantations are now devoting 822 acres for the 1914 and 1915 crops. By far the greater portion of this is on the island of Oahu, which contributes 699 acres or 85% of the whole amount. Hawaii furnishes 103 acres and Kauai 18 acres, while Maui reports but 2 acres.
>
> Looking more closely into these figures we find that Ewa Plantation has a greater area in Hawaiian seedlings than all the rest of the Territory put together, or 467 acres against 355 acres to express the fact in figures. Of the remaining 355 acres the Oahu Sugar Co. claims over half, so that these two plantations have 650 acres against 172 reported from the other plantations of the Association.

The acreage census of 1913 showed no areas as large as one acre of H 109 on Hawaii or Kauai. The late George F. Renton then had at Ewa 25 acres of H 109 in his 1914 crop, and another 25 acres in the 1915 crop. Of H 20 there were 12 acres in the 1913 crop, and 128 in the 1914. Of H 227 there were 12 in the 1914 and 28 in the 1915.

These figures indicate that Mr. Renton, with less than four years' experience with H 109 on the plantation, had already discerned its commercial possibilities.

It should be noted also that at Waipahu, E. K. Bull had 12 acres of H 109 in the 1915 crop. At Waialua, W. W. Goodale had one acre in the 1914 crop and 8 in the 1915.

On Maui, H. B. Penhallow reported one acre of H 109 in the 1915 crop.

Fifteen plantations, in all, were experimenting with H 109, but only those named above had extended the variety to an acre or more.

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* Circular 19, Agricultural and Chemical Series, "A Report on the Question of Cane Varieties."

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† Including Louisiana Striped, which is supposed to be the same variety.

The *Record* for June, 1913, had an article, "Seedlings at Ewa," giving returns from seedlings "from the standpoint of extent of area, the most important results that have yet been published on these canes." A half acre of H 109 had yielded 8.88 tons of sugar and five other Hawaiian varieties had done even better.

1914

Experiments harvested at Waipio in 1914 showed H 109 among the seedlings which outyielded Lahaina and Yellow Caledonia by wide margins.

The *Record* for June, 1914, reported that a field of 25.2 acres at Ewa planted August, 1912, harvested April, 1914, had yielded 8.66 tons of sugar per acre against 5.16 from an inset of Lahaina. In the same issue, figures published through the kindness of Mr. Renton showed H 109 to be second in a list of twelve Hawaiian seedlings, the juice of H 109 being richer than any of the rest.

1915

In 1915, the Ewa Plantation Company reported over 1,071 acres of H 109 in their 1916 and 1917 crops. Oahu Sugar Company had 373 acres, and the Waialua Agricultural Company had 120 acres. A number of other plantations had begun to spread this cane.

The early predictions in connection with the Hawaiian seedlings had come true. A cane of great commercial worth had been found.

There were, however, but 13 acres as yet on Maui, 10 at the Maui Agricultural Company and 3 at Wailuku.

On Kauai, the Hawaiian Sugar Company reported 20 acres and McBryde Sugar Company 107.

1916 to 1922.

The rapid expansion of H 109 taking the place of Lahaina as that variety rapidly declined, is best shown in statistical form, giving the area of two crops at a time so as to include the cane area as a whole:

	H 109	Lahaina
1913-1914	26	80,905
1915-1916	597	72,459
1917-1918	3,928	65,474
1919-1920	11,889	53,679
1921-1922	30,578	32,617
1923-1924	52,487	13,486

In 1922, the largest area in H 109 at any one plantation was 9,403 acres at the Hawaiian Commercial & Sugar Company. Ewa reported 7,328 acres. Oahu

Sugar Company had 6,577 acres, and Waialua Agricultural Company, 2,683. Other plantations with extremely large areas were:

Hawi Mill & Plantation Company	882 acres
Hawaiian Sugar Company	2,335 "
McBryde Sugar Company	2,611 "
Maui Agricultural Company	4,360 "
Pioneer Mill Company	3,528 "
Honolulu Plantation Company	3,085 "
Kahuku Plantation Company	1,145 "
Waianae Company	1,509 "
Waimanalo Sugar Company	857 "

As this is written, September 10, 1923, the area of H 109 in all probability exceeds 60,000 acres by a wide margin.*

Notes on Insect Pests in Samoa

By O. H. Swezey.

While in Samoa four weeks during September, 1923, every opportunity was taken to make observations on insect pests of economic importance there.

Apparently the most destructive pests are those of the coconut and banana, and they appear to be such as have comparatively recently arrived there from elsewhere, probably from other islands of the South Pacific.

The worst pest on sugar cane is the borer, the same kind that we have in Hawaii. As cane is grown in Samoa only for thatching the native houses, the damage done by the borer is not taken so seriously as if it were a commercial crop.

Insects of Sugar Cane.

Perkinsiella vitiensis Kirk. This leafhopper was usually to be found in patches of sugar cane, though not abundant enough to be injurious. In fact the insects themselves were rather so scarce as to be difficult to find, but their presence was known by the discoloration of the midrib of the leaves where eggs had been deposited. Very few eggs were found anywhere, and I failed to find any that were parasitized. However, a few of the little round exit holes were found which indicate where the egg-parasite *Ootetrastichus* had issued. This was very likely the same species (*Ootetrastichus beatus* Perkins) that occurs in Fiji. The adult parasite oviposits in eggs of the leafhopper. In developing, the parasite larva consumes the leafhopper egg in which it has hatched, it then eats the other 2 to 7 eggs of the same cluster of leafhopper eggs. Having obtained its growth the larva transforms to the pupa and adult in a small cavity in the leaf tissue, and gnaws the tiny round exit hole to make its escape when fully matured. This egg parasite was introduced from Fiji to Hawaii in 1905 where it rendered valuable assistance in checking the cane leafhopper (*Perkinsiella saccharicida*

* The census of November, 1923, showed that there were 66,141 acres under cultivation.

Kirk.) occurring there. A single specimen of the egg-parasite was collected in a cane patch on the island of Tau of the Nanua group, which proves to be the Fiji species mentioned.

Rhabdocnemis obscura (Boisd.). The cane borer was generally present and quite injurious. In some places worse than others, sometimes scarce and hard to find in cane patches. Often it was easier to find in coconut trees, where its larvae were in the bases of old leafstalks, usually the stubs where leaves had been cut off.

A colony of the New Guinea Tachinid fly parasitic on the larvae of this borer was sent to the Naval Station, Pago Pago, in 1918. I learned that the flies had been liberated in a cane patch at a Samoan village on Pago Pago harbor. As I was not able to find any of the parasites anywhere that I looked, it must have failed to become established. If it had succeeded in establishing, it could have spread quite generally by this time. Other colonies of this parasite have recently been sent in further attempts to establish it there.

Elytroteinus subtruncatus (Fairm.). A beetle which has been known as the ginger weevil, or else a very closely related species was found in cane along with the cane borer in a cane patch on the side of the mountain above Fagasa village. Quite a number of larvae were found, mostly in broken off canes lying on the ground and already somewhat bored by larvae of *Rhabdocnemis obscura*. A few pupae were found which were saved till they matured to the adult beetles.

Longicorn beetle. A few larvae of a Longicorn beetle were found in dead canes on the ground in the same cane patch at Fagasa. These were not reared, so their identity is not known. They were probably some dead-wood borer, and not a particular cane insect, probably only attacking dead canes.

Melanitis leda Linn. On two occasions the larva of this butterfly was found feeding on cane leaves. One of them was reared, thus proving its identity. It is a green caterpillar, probably a special cane insect, though not numerous enough to be considered a pest. I do not know if it feeds on other plants than cane. It occurs in Fiji, and quite widely distributed in the South Pacific.

Cosmopteryx dulcivora Meyr. The larva of some small species of moth was found boring in the midribs of cane leaves, fairly common, but not specially injurious. I failed to rear any adults, but it is likely to be the species here given which occurs in Fiji with similar habits.

Mealybugs: *Pseudococcus sacchari* and *P. calceolariae*. Both of these species of mealybugs were found, the former more common than the latter. Both feed on the cane stalks at the nodes, inside of the leaf sheaths. No parasites were found associated with these, nor ladybeetles feeding on them.

Aleyrodes bergii (Sign.). In several different places, colonies of an Aleyrodid were found on cane. They were usually on the underside of the leaf and near the base, and in quite dense clusters of a few hundred insects occupying a space of 2 to 3 inches along the leaf. They were not numerous enough to cause any significant injury. This species also occurs in Fiji.

Diaspine scale. In the cane patch at Fagasa, a few stalks of cane were found having a scale on them near the joints. Not numerous enough for injury. The species has not been determined.

Coconut Insects.

Oryctes rhinoceros Linn. The rhinoceros beetle seems to be considered the most important of all insects that affect the coconut in Samoa. The injury is done by the large adult beetles feeding and burrowing in the growing crown of the coconut tree, where they may cause such injury as to result in the death of the tree, or they may only mutilate the undeveloped leaves so that they cannot become fully developed and of proper service to the tree, or it may be that the undeveloped fruiting clusters are so much injured as to prevent the bearing of nuts. The appearance of the newer mutilated leaves serves to indicate when and where the beetle is prevalent. The larvae or grubs are not injurious but feed in dead and rotting stumps and logs.

Searching out these grubs and destroying them is the chief control measure being practiced. It seems to be quite effective when persistently and thoroughly carried out. One day per week is designated as "beetle day", on which the natives are required to make special search for these grubs. Many thousands of them are thus found by chopping up old logs and stumps. Their eggs are also found in this way, and a few of the beetles themselves, all of which are destroyed. Much benefit is derived in this way, but the work would be greatly facilitated if the coconut groves were kept free of the native jungle of brush and vines that has such a tendency of rapidly choking up the space beneath the coconut trees. On account of this undergrowth there is great difficulty in finding the breeding places of the beetles and many will escape detection, and thus enough grubs go through to maturity to keep the beetle continuously going.

Rhabdocnemis obscura (Boisd.). The sugar cane borer is found quite commonly in coconut trees. The beetles may be found behind the bases of the leaves where they can readily hide amongst the fibrous matter, but the grubs were usually found in the bases of the leafstalks, and mostly in those that had been cut off leaving a stub remaining on the tree. These cut off ends provided a place where the adult beetles could conveniently lay their eggs, which accounts for the grubs being more often found in such positions. On account of this habit of feeding in these places, this weevil is not of important injury to the coconut trees.

Diocalandra taitensis (Guer.). The Tahiti coconut weevil was found quite abundantly in places. It is much smaller than the sugar cane borer. Its larvae feed in the edges of the lower part of the leaf stalk, and as it is the older leaves that are most often attacked, they are not significantly injurious to the trees. They, too, are likely to be more abundant in stubs of cut-off leaves.

Promecotheca reichii Baly. This is a Hispid beetle whose larvae are leaf-miners in the leaflets of coconut. The egg is laid on the surface of the leaf, and the young larva on hatching bores into the leaf and feeds on the inner green part of the leaf, producing a dead spot on the leaf where the green matter has been eaten away. The larva transforms to a pupa and eventually to the adult beetle within the mine in the leaf. This was not observed to be abundant enough to be particularly injurious.

Leaf Caterpillar. Everywhere the coconut leaves showed evidences of the feeding of some insect which ate off the surface in small spots, leaving one epidermis of the leaf and giving the appearance of numerous small dead spots on the leaflets. No insects were found actually doing this eating, but it was considered as being the work of caterpillars of some small moth which was out of season at the time I was there. I thought at the time that the appearance of the leaves was different from that caused by the little moth, *Levuana iridescens,* which injures coconut leaves so badly in Fiji.

Graeffea minor Br. Stick insects were found feeding somewhat on coconut leaves in a few places. In feeding they consume the whole substance of the leaf, so that the leaflets have ragged edges, or may even be eaten down to the midrib. A larger species, *Graeffea cocophaga* (Newp.), is also said to feed on coconut leaves, but I failed to find any of these. The damage by these insects did not seem to amount to much.

Chrysomphalus rossi (Mask.). This scale insect was found frequently on coconuts, occurring on or beneath the scales at the base of the nuts; also on other parts of the tree. It did not seem to be particularly injurious.

Scholastes bimaculatus Hendel. This fly appears to be attached to the coconut, but perhaps not as a pest, as it apparently breeds in decaying nuts. The fly is usually seen on fallen nuts lying under the trees. What I considered their eggs were found by thousands beneath the scales at the base of immature coconuts lying on the ground, that had fallen off accidentally by the wind, or had been partially eaten by the flying fox, which damages the young nuts on the trees a good deal. I also found very numerous small pink maggots feeding in the decaying husk of similar nuts lying on the ground, which I took to be the maggots of this fly. However, these conclusions are not to be given too much importance. Further observations are necessary to fully learn the life history and habits of the fly and its exact relations to coconuts.

Termites. A species of termite that is very abundant in the forests of Samoa, builds large, black, rough-surfaced nests on the trunks of trees from one to ten feet or more from the ground. They feed in the trunks, also build narrow covered runs about on the surface of the tree trunk, often extending to a considerable elevation in the tree. Beneath these runs the termites feed on the bark.

Coconut trunks frequently bear these termite nests, a favorite position for the nest being at one of the numerous notches that have been cut into the trunks by the natives to facilitate climbing the trees for the nuts. Besides providing a place for the entrance of termites to the trunk, these notches also present opportunities for decay to set in which diminishes the productivity of the tree and shortens its life. This phase of it is probably more detrimental than the injury by the termites, and it seems to me that this practice of notching the trees should be discouraged.

Banana Pests.

Cosmopolites sordidus (Germ.) The banana weevil was found in a number of places. Perhaps it has only lately become established and not yet generally spread. The larva of this beetle is a fat, white, legless grub which bores in the

corm and base of banana stems. The adult is a black snout-beetle and may be found in the same places and beneath the dried leaf bases at the base of banana stems. This pest is very destructive to bananas where it occurs in Fiji, Queensland, Java and probably most of the groups of islands between there and Samoa. Where numerous in the base of banana stems these are weakened and may easily fall over, or the plant prevented from normal growth and fruiting, and the young suckers may be entirely killed. This pest has become very serious in Fiji and it is very difficult to devise satisfactory methods of control. It is likely to increase to that condition in Samoa.

Nacoleia octasema Meyrick. The banana scab moth is generally prevalent. The caterpillars of this moth feed among the flowers and the green bananas on the bunch. Where they feed on the surface of the young growing bananas it does not always prevent their growing to normal size, but the surface where eaten assumes a scabby appearance which is detrimental to the sale of the fruit. The bunches, too, are unattractive where littered up with the black frass from the caterpillars.

This pest occurs from Java to Queesland, Solomon Islands, and to Fiji and Samoa, and no doubt it occurs at all intervening islands. I think that it has not been previously reported in Samoa, and may be of somewhat recent introduction there. In Java, dusting with pyrethrum powder is said to be effective in controlling the pest. The pyrethrum is mixed 1 part to 3 parts of sifted wood ashes or lime, and dusted into the opening flower cluster or among the small growing bananas by means of a syringe-like duster.

Papaia Fruit-fly.

Chaetodacus xanthodes (Broun). This fruit-fly was reared from immature fruits of papaia at Amauli towards the east end of Tutuila. I did not find it generally attacking papaias, but it is not confined to papaia, as it has been reared from guavas and granadillas. Fruit-fly maggots were found in aligator pear, and in several kinds of native fruits in the forest, but none of these were reared. so we do not know if they were this species or other species of fruit-flies.

Taro Insects.

Chaerocampa celerio (Linn.). The larvae of this medium sized hawkmoth were occasionally found feeding on the leaves of taro, not numerous enough to be considered injurious, however. It occurs from India to Java, Borneo, Australia, and Fiji. The large green caterpillars with a horn at the tail end may be readily picked off and killed when noticed.

Megamelus proserpina Kirk. This is a small leafhopper found on the underside of the leaves, and often quite numerous though not especially injurious. It occurs in Fiji, Java, the Philippines and probably intervening regions.

Several other kinds of leafhoppers were collected on taro leaves, but were not considered as particularly attached to taro the same as *M. proserpina* is.

Aphidid, an undetermined plant louse, was also found on the leaves of taro, but not causing serious infestations.

Insects of Cucurbits.

Glyphodes indica Saund. The larvae of this widely spread leafroller moth were occasionally found on cucumber vines, but in no case were they numerous enough to be considered a pest.

Aulocophora fabricii ? A leaf-beetle probably of this species was quite abundant on squash and pumpkin vines.

As nearly all of the insects above mentioned do not now occur in the Hawaiian Islands, and as some of them are serious pests where they are, we may consider ourselves fortunate if they can be kept from reaching our islands.

Of the 10 insects on sugar cane mentioned only 3 are at present infesting cane in Hawaii: the borer and the two mealybugs. Some of the others, although not serious pests on cane in Samoa might possibly become pests if they reached Hawaii, the same as the leafhopper from Australia became such a bad pest, whereas it was not a bad one in Australia.

The most of the coconut insects are not present in Hawaii either. The leafroller that we do have, however, causes the leaves to look more dilapidated than they do in Samoa with several kinds of insects feeding on them. Our one pest on coconut leaves is too much, we surely do not want any more.

The banana borer and the banana scab moth would ruin the banana industry in Hawaii if they should gain access here, and there is no telling what the papaia fruit-fly might do here, as it has been reported bred from pineapples from Fiji, though not fully substantiated.

As Samoa is the closest tropical neighbor from which steamers are coming regularly, it is the most likely place from which some of the already widely distributed tropical insect pests could accidentally reach Hawaii, and makes it urgent that a constant lookout is maintained to prevent as long as possible any more such pests arriving here.

The Identification of Cane Varieties*

By Twigg Smith.

For the past few months I have been studying and making drawings of the characteristics of a great many of our canes with the object of testing the constancy of certain morphological characters used by Dr. J. Jeswiet of Java, as an additional means of classification and identification of sugar canes.

I have found that his system can be applied here and that the characters he writes of are constant.

This system of Dr. Jeswiet's is a very valuable addition to the usual agricultural description by which cane is generally recognized.

* Presented at the meeting of the Association of Hawaiian Sugar Technologists, October, 1923.

Not only is it possible to recognize the standard varieties, but it is possible to make a description of seedlings so that wherever they are grown they too may be recognized.

Later, it will be possible to tell the parentage of seedlings by these additional characteristics.

The system may be likened to the Bertillon system.

In Java where they have specialized in seedling cultivation for years, it became absolutely necessary to have some definite means of identification other than the outward appearance of the cane growing in the field. We in Hawaii are now confronted with the same problem. We have our standard varieties pretty well known by appearance, and it is possible for many men expert in cane culture to pass through a field and pick out each variety, but it would be extremely difficult to do so under different climatic conditions or with seedlings. The seedlings in Java were mostly secured by the caging or bagging method, and were therefore of known parentage, but as it is not possible to get even two seedlings that are exactly alike, even from the same tassel, it was becoming increasingly difficult to recognize the seedlings once they had left the experiment station. It was necessary to find some morphological characters that under all conditions would remain constant or nearly so. It is well known that the usual means by which cane is recognized is faulty, as the appearance of cane is so subject to variation under different climatic conditions.

I do not mean that the usual method of recognition is valueless by any means, but that as some of the principal points on which recognition of variety is based are valueless under different growth conditions, it should be used with reservations and checked by means of Dr. Jeswiet's system.

First let me go over the usual method of identification. On mature cane we look for stalk, roots, and leaves. On the stalk for length, position and number or quantity per stool. Every stalk has a number of nodes and internodes. The internodes themselves are distinguished by color, waxlayer, shape, circumference, length or position, by the presence or absence of the eye groove, cork cracks, and growth cracks, growth ring, root ring, number of root eyes, and color of the rind fibre.

The sheath of the leaf is attached at the joint or node, and when it is removed the eye is seen, just above the leafsheath scar.

Now most of the points mentioned are subject to variation with a change of environment or difference in fertilization or water supply.

Stalk length and diameter are enormously influenced by climatic conditions or change of soil. On poor soil long cane may grow short, and thick cane thin, and the individual internodes likewise are affected.

Color is very changeable; exposed stalks, and those on the outside row, are often of a different color than the inside ones. In H 109 for instance, the color may run from yellow green to dark purple.

However, the color impression of full grown cane is fairly constant and is of great use, but it must be used with reservation and never can be used solely as a basis for cane classification. The color change may become permanent, however, by bud variation or vegetative mutation. The other parts used in

description are all more or less subject to variation, perhaps the most reliable are: First, fine cracks, called cork cracks by some writers, running the length of the internode, in the ground tissue, which later may dry up and may change to black lines. Second, growth cracks; a great many canes show these and they appear to be constant. Third, shape and location of the root ring or band, not its color, and the number of rows of root eyes seen in the root ring. In the interior of the cane joint, the rind fibres may be brown or colorless. There are many varieties of cane that have brown rind fibres, and it is a very constant characteristic for the variety.

Those items and some other characteristics which the agriculturist or cane grower becomes familiar with have made up the usual method of identification and as long as clearly differing varieties were being dealt with it was not difficult for one familiar with cane to differentiate. But when it came to seedlings of very mixed parentage, as is the case where field pollination is carried on, or even when dealing with thousands of seedlings of known parentage, it becomes exceedingly difficult to authoritatively separate them and the result is always open to doubt.

Here is where Dr. Jeswiet started. He found that the usual method of identification was at fault, and that many canes of similar appearance but entirely different sucrose content were being called by the same names. He found many canes of the same variety were being called different names in different localities. He then searched for and found certain morphological characters that would remain constant despite climatic or agricultural changes. He states that "In the structure and hairing of the normal eyes we have an exceptionally reliable and good indication of variety as well as in the structure and hairing of the leaf sheath, its juncture with the blade, the root zone, etc." He prepared plans of the types of eyes and marked the hairgroups as they were found, and at present there are 31 positions where hairgroups may be found on the eye, and 21 on the sheath, its juncture with the leaf, and the blade.

We understand by eye the cane bud, of which there is always one (except in rare cases when the eye is missing or when there may be double or triple eyes), growing in the root ring above the leaf sheath attachment.

They alternate to the right and left of the stalk, generally straight above one another and are absent in upper joints of the flowering stalks.

The eye is enveloped by a first or outer scale and grows from the stalk. On the outside of the eye the scale is in two halves, the upper one passing over the lower to a greater or lesser extent. I have found some eyes with no break in the outer scale. This outer scale may or may not have wings which also may vary much in size and in their manner of attachment. Again the wing may have ears attached to its free edge as I found to be the case with a cane imported by the Experiment Station from Java a short time ago.

There are two main shapes of eyes, round, and oblong or longitudinal. With round eyes the wings are found attached above center, and with oblong below. The basal parts of attachment are called wing corners. The round eyes have a more or less central, the oblong eyes an apical germpore. By germpore is meant the germination point through which the young shoot emerges, either by pushing

aside the flaps of the enveloping scale or splitting it. Since the scale nerves come together at the germpore, the round eyes have a radially shaped nervature, whereas the oblong pointed eyes have more or less straight nerves.

Between these two shapes of eyes many transitions occur. It may happen that under unfavorable conditions a variety with round eyes may develop oblong or pointed eyes. With the changes in shape the veining changes and compact hairgroups may become long stretched ones or vice versa. Notwithstanding this variation in shape, veining and germpore are reliable characteristics in the variety description when sufficient material is available. The eye is not always growing close to the leafsheath scar, it may be in one variety and in another it may be much higher up on the stalk. Also it may be tightly pressed against the stalk, or standing out from it.

All eyes are more or less haired.

These hairs are either white, and range from short bristles to long soft hairs, or brown black and then always short. The latter class is considered primitive and is in many cases covered or pushed aside by the longer white hairs.

The kind of hairs is very different for the different varieties and they are remarkably constant in their grouping.

It is clear that both the presence as well as the absence of the different groups are considered in the description.

Of course, the appearance and the size of the groups as well as the length of the hairs themselves are subject to variation, which may be rather large for certain groups, but in a comparatively small number of sticks taken at random a sufficient number of eyes can be found which correspond to the typical hairing.

The leafsheath, the blade and their juncture, carry groups of hairs that Dr. Jeswiet also has numbered and shown on his plans.

The ligule is a small strip of tissue at the juncture of the sheath and blade. It may or may not be haired. The auricles which are an appendix to the leaf-sheath may be large or small. Some varieties have no auricle, some only one. They also have characteristic hair groups, one of which (group 70) assisted in identifying a cane in the Java importation, P. O. J. 36. The* joint triangles are the triangular zones at the juncture of blade and sheath above the ligule. They differ very much for different botanical varieties in shape and hairing. At times they are almost totally absent. They are generally different in color to the leaf and with their hairing help in variety division. The leafsheath and blade have groups of hair which are characteristic for group and variety divisions.

I do not intend to create the impression that it is only necessary to examine a few eyes or a leaf or two of any cane in order to be able to identify it. There are a few varieties that so far have been easy to place and some that are hard.

It will be necessary to carefully gather and file the deviations and variations from standard types of eyes, etc., for each variety and gradually build up a reference library, so that recognition will be made easier.

* The joint triangles are called articulation triangles by Dr. Jeswiet of Java, basal triangulares by Wm. F. L. Fawcett of the Tucuman Experiment Station, and have been called dewlaps by Dr. Lyon of this Station.

It is not so hard to distinguish between the older canes, such as Badila, Striped Mexican, Caledonia, Lahaina, H 109, Uba, etc. The difficulty lies in separating and recognizing parentage of seedlings. Until we have examined many seedlings of known parentage it will be a difficult problem, as there is no method of arriving at how much of the hairing of eyes and leaves are transmittible characters. However, if we are able to make accurate descriptions of seedlings and continue to file them away it will be of immense value.

Some of the characteristics of parent canes are easily distinguished in their progeny. For instance, I am reasonably sure that many of the seedlings of Yellow and of Striped Tip now growing at the Manoa Substation have D 1135 for their other parent. Again, the known hand pollinated crosses of D 1135 and Uba propagated in 1923 and now growing at the Makiki Station show characters of both parents. Also a few stools of seedlings in one plot at the Station were marked on the blue print with a certain number denoting crosses between Striped Mexican with the other variety unknown. They were so much like Striped Mexican in appearance that I examined them carefully and found that they were Striped Mexican. Later I found that the seedlings had died and had been replaced by Striped Mexican seed pieces, but the blue print had not been changed.

H 109 possesses many different shaped eyes but more of a certain definite type and nearly always with serrated or notched edges. With all the differences in shape the hairing is remarkably constant and yet in growth habit and appearance this variety differs greatly with its location.

Another instance of the practical value of this system of identification was in checking the recent importation of Java seedlings.

The Experiment Station some months ago received cuttings of four varieties from Washington, D. C., which originated in Java and have been grown successfully in many parts of the world.

They were originally produced from known parents by the caging or bagging method, crosses between Cheribon and Chunnee and Striped Preanger and Chunnee. Cuttings were sent to Washington, grown there, and now cuttings from that growth were sent to the Experiment Station here. They are now growing in the Pathological Plot. Dr. Jeswiet described three of these canes in the Archief of the Sugar Industry of Java and published drawings of the eyes.

I have examined these canes and find that they check with Dr. Jeswiet's description. This examination was made at 7 months of age, saving a wait of many months till the cane could be tested in other ways. We are reasonably sure now that the canes are of the varieties they were supposed to be and they can be safely distributed as such to be tried out under our different growth conditions.

The plans showing the hairgroups as used by Dr. Jeswiet in this system of identification were published in the *Record* of October, 1923, beginning on page 326.

We have just received from Dr. Jeswiet new drawings showing the disposition of all groups up to date and now wish to correct errata and add new groups to the article in the October *Record*.

Group 28. (Should read:)

A group of short hairs growing above and pointing into the germpore and surrounding it at the upper half.

This group is present in EK 28, Bandjermasin hitam, and other canes.

Group 27. (Omitted before.)

A small group of rather short white hairs somewhat beneath the top of the overlapping scale.

In some canes this top is abnormally developed and then the group is very distinct.

The positions of groups 52 and 58 should be reversed, descriptions remaining the same.

Group 69. (Should read:)

One or more rows of isolated soft hairs on both sides of the midrib on the basal part of the leafsheath, on the outside.

Very rare, found in Loethers, Java, and some of its seedlings.

Some Photographs of Primitive Methods of Sugar Production

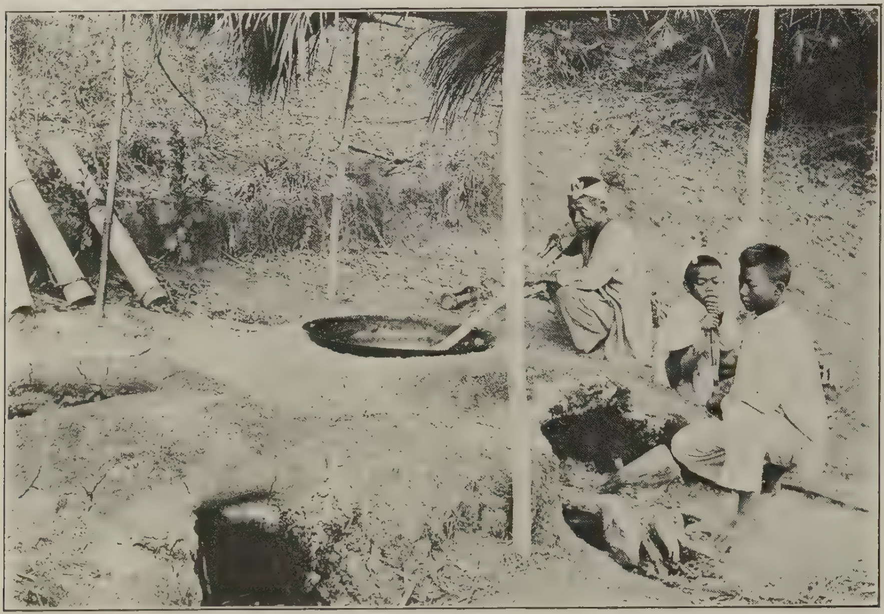
The accompanying photographs show some of the primitive methods of sugar production in the Philippine Islands, but slightly changed, if at all, from the original Chinese methods of cane growing, extraction and boiling. To those in the highly specialized branches of sugar production in Hawaii there may be a

justifiable feeling of satisfaction in the progress made from such methods of sugar manufacture of early days.

The first photograph shows the plowing of fields by the heavy, slow-moving carabao, or water buffalo. These animals have few or no sweat pores and there-

fore can be worked only 3 to 4 hours a day in the usual hot weather in cane fields. The plows shown in the photograph are of wood and turn the soil over to a depth of possibly four inches except under unusual conditions. Such wooden

plows used in the Orient have but one handle as compared with the two-handled plows of western countries.



The second photograph shows the furrowing by the water buffalo, and planting. The women doing the planting in this case received from forty to sixty centavos per day without food or lodging, equivalent to twenty to thirty U. S. cents per day.

The third photograph shows the milling equipment in detail. The power is furnished by a carabao and in this case there are two vertical rollers of stone fitted to wooden shafts; the gears in the photograph are of wood. There are many muscovado mills which have advanced to the use of small, steam-driven, steel rollers.

The fourth photograph shows the boiling house. At the left of the picture are three bamboo tubes which are used to carry water or to take the juice from the mill to the kettles.

The fifth photograph shows the boiling house of a much larger and improved muscovado mill. Of interest in this photograph are the dippers made of empty gasoline tins on bamboo poles and the bamboo pipes to transport the juices from one part of the house to another.

These muscovado mills, although they can still be seen, are very rapidly disappearing in the Philippines now, their place being taken by factories of the Honolulu Iron Works, such as that of the Hawaiian-Philippine Company, with daily capacities of as high as 2,500 tons of cane, and with production in one case of 35,000 tons of centrifugal sugar each season. Similarly wooden plows are seldom seen in use now. The photographs are from the collection of the Philippine Bureau of Science.

H. A. L.

Cane Deterioration

A Summary.

By J. A. Verret.

We present herewith a summary of the data we have bearing on the loss of sugar in the cane which takes place in the interval of time between cutting or burning and milling.

This loss takes place in two ways. There is a deterioration of juices whereby sugar is destroyed, and there is an indirect loss due to loss of cane weight caused by evaporation. In order to determine the total loss it is necessary to not only determine the juice deterioration but also to know the loss in weight of the cane.

Work in Foreign Countries.

It appears that but little work along these lines has been done in other countries, as a search in our library shows but few references to this subject.

The few references found are given briefly as follows:

Noel Deerr reports the following as the mean of seven experiments conducted by himself on the evaporation of cane when exposed in heaps of about fifty pounds:

Days cut	1 day	2 days	3 days	4 days	5 days
Per cent loss in weight	2.19	4.03	5.49	7.37	8.57

He does not report weather conditions during the tests, nor does he state where they were conducted. Our losses in weight were of about the same order as those reported by Deerr.

Weinberg gives the following data, showing the loss of available sugar in cut cane:*

Days Cut	0	1	2	3	4
Available sugar per 100 A. S. in original sample....	100	97.3	92.0	78.6	67.9
Total Loss of A. S.	0	2.7	8.0	21.4	32.1
Daily Loss of A. S.	0	2.7	5.3	13.4	10.7

J. A. Hall, Jr., from experiments conducted in Argentina, with a number of different varieties of cane, pointed out that they did not deteriorate at the same rate, as the following selected list shows:

PURITIES OF THE JUICE.

Variety	Fresh	6 to 8 days	9 to 11 days
Louisiana Striped	87.9	82.7	72.1
Java 36	84.5	58.2	51.4
Java 234	87.3	70.5	60.8
Kavengire	83.8	41.1	32.6

Comparatively cold weather prevailed during these tests, the temperature varying from a little above 32° F. at night to 86° F. in the day, with no rain.

Muller von Czernicky, working in Java, found that the purity of the juices of cane stored for five days indoors dropped from 94 to 82, and when the cane was left one day in the field and then stored five days indoors, that the drop was from 94.6 to 74.2 purity.

In a recent publication, "The Cultivation of Sugar Cane in Java," by R. A. Quintus, the author says:

> Cut cane should be removed the same day, since if it remains behind on the reaped field, exposed to the sun, the cane sustains a great loss of available sugar. The great retrogression in point of "available sugar" percentage in canes that remain exposed to the sun for one or more days appears clearly from the figures below:

Number of days exposure to the sun	Brix	Quotient Purity	Glucose per cent	Loss of weight per cent	Available sugar per cent
0	21.3	94.3	0.2	0.0	16.2
1	22.1	94.6	0.3	2.1	16.0
2	22.4	86.4	1.0	3.3	13.5
3	22.8	79.7	1.9	4.3	11.6
4	22.8	77.1	2.3	5.4	10.8
5	23.8	74.1	?	6.6	9.9

Much available sugar is therefore lost by inversion, while the weight of the cane is diminished by drying.

* We do not understand the mathematics, but this is as reported by the author.

H. Pellet, working in Egypt, found that the factors influencing deterioration were (1) the size of the cane; (2) the density of heap; (3) the temperature of the atmosphere; and (4) the force of the wind.

He found that small cane lost more weight, and that the denser the pile the less the loss. Windy days increased the loss. Quiet, moist days decreased it.

Local Work on Deterioration.

The first work done on this subject in these Islands of which we have record was done by Mr. P. Messchaert, Chemist at Oahu Sugar Company in 1910.

He took cane from Field 30, a car at a time. The cane was stripped and weighed. It was then placed upright against an iron railing and trash piled about it and burned. The amount of trash used was that from the area from which the cane was taken.

He summarizes the results of three tests as follows:

PERCENTAGE AVAILABLE SUGAR LEFT IN GREEN CANE AND IN BURNT CANE FOR TWELVE DAYS AFTER CUTTING.

	Green Cane				Burnt Cane			
Table	Test 1	Test 2	Test 3	Average available sugar	Test 1	Test 2	Test 3	Average available sugar
Loss in Weight					4.75	3.25	7.90	5.30
First day.......	100	100	100	100	90.7	94.9	95.4	93.7
Second day	97.1	101.5	101.4	100	85.4	95.0	93.8	91.4
Third day......	93.6	98.7	101.4	97.9	86.0	94.4	92.9	91.1
Fourth day.....	96.6	97.4	98.1	97.4	84.3	83.9	88.0	90.9
Fifth day	97.6	87.5	93.6	92.9	82.7	95.6	88.4	88.9
Sixth day	94.7	86.6	88.9	90.1	80.4	86.4	83.6	83.1
Seventh day....	89.9	86.5	84.3	86.9	78.2	88.3	78.6	81.7
Eighth day.....	88.5	88.5	84.5	87.2	77.5	81.1	71.7	76.8
Ninth day......	87.1	90.0	77.9	85.0	81.6	86.1	64.6	77.4
Tenth day......	83.1	87.7	78.6	83.1	77.1	77.3	62.9	75.8
Eleventh day...	87.6	85.5	75.5	82.9	77.0	69.5	58.0	68.2
Twelfth day....	85.5	84.1	70.6	80.1	68.3	74.3	49.4	64.0

It is interesting to note here that Messchaert found a loss of 36% from burned cane in twelve days or 3% a day. The Station, ten years later in a much more elaborate test at Ewa found a loss of 2.97% per day for about the same period of time.

Apparently Messchaert's report did not attract much attention for it was not until 1919 that the matter of cane deterioration was again taken up in a systematic way, when Verret and McAllep started some work in Honolulu and planned experiments to be conducted on the plantations.

A total of about 30 experiments was conducted during 1919 and 1920.

The results obtained by Verret and McAllep are given as follows:

The data presented were obtained under Honolulu conditions with 50-stalk bundles and embrace three widely planted varieties. As shown in the following tabulations, one may note, in the first place, the loss in weight independently of the deterioration in

quality; secondly, an estimation of the tons of cane required to make a ton of sugar for each two-day interval. Finally the cumulative effect of both of these significant losses is shown by combining the two and expressing the percentage of loss of available sugar with each succeeding two-day period.

LOSS IN WEIGHT.

	D 1135	Lahaina	H 109
Fresh	0	0	0
2 days old	4.5%	4.6%	4.0%
4 days old	8.1%	8.7%	7.4%
6 days old	9.7%	12.5%	9.9%
8 days old	12.0%	15.4%	13.0%

DECLINE IN QUALITY AS SHOWN BY QUALITY RATIOS.
(Tons of Cane per Ton of Sugar.)

	D 1135	Lahaina	H 109
Fresh	7.30	7.08	7.34
2 days old	7.63	7.15	7.73
4 days old	9.08	8.45	8.27
6 days old	10.41	10.56	8.64
8 days old	11.04	11.33	10.47

LOSS OF AVAILABLE SUGAR AS FOUND BY COMBINING THE WEIGHT LOSSES AND THE DECLINE IN QUALITY.

	D 1135	Lahaina	H 109	Average of the Three Varieties
Fresh	0	0	0	0
2 days old	8.8%	5.7%	2.8%	5.8%
4 days old	27.0%	24.7%	12.2%	21.3%
6 days old	34.7%	41.4%	18.0%	31.4%
8 days old	42.0%	47.4%	34.9%	41.4%

In April, 1919, a cane fire occurred on Hutchinson Sugar Plantation Company. It took fifteen days to grind this burned cane. C. Brewer & Company supplied us with data showing the juice deterioration during this period. Taking account of the estimated loss in cane weights the following losses took place:

No. of Days After Fire	% Sugar Loss
5	11.7
6	14.9
7	15.9
8	20.4
9	26.6
10	35.8
11	41.0
12	47.9
13	50.6
15	57.2

Here the loss was 2.35% per day for the first five days. But from the seventh day on the losses increased rapidly and amounted to 57% in fifteen days.

In the same year a deterioration test was conducted at the Hawaiian Sugar Company with bundles of cane and resulted as follows:

Days after burning	% Loss in weight	% Loss in Sugar
1	3.94	6.0
2	6.56	10.4
3	....	....
4	11.29	29.5
5	15.11	38.2
6	18.22	34.4
7	21.80	32.2

On account of the small samples used and the lack of repetitions the results are not concordant, but indicate a possible loss of about 4% a day.

In July and August, 1919, Paauhau Sugar Plantation Company conducted two tests. The summarized data follow:

LOSS IN WEIGHT IN PER CENT.

Days after cutting	1	2	3	4	5	6	7	8	9
First test	1.9	3.3	4.7	6.2	5.0	5.9	7.9	10.1	11.4
Second test	2.7	3.9	4.0	4.6	6.7	5.7	7.4	7.1	8.7
Average	2.3	3.6	4.3	5.4	5.8	5.8	7.6	8.6	10.0

LOSS OF SUGAR—IN PER CENT ORIGINAL SUGAR.

Days after cutting	1	2	3	4	5	6	7	8	9	10
First test......	...	5.6	19.2	20.6	26.8	33.9	32.6	29.9	30.9	....
Second test....	2.4	3.2	6.8	10.5	10.8	15.7	29.0	7.8*	21.5	30.5
Average	2.4	4.4	13.0	15.5	18.8	24.8	30.8	29.9	26.2	30.5

Small samples were used and the results are not concordant from day to day. But it is interesting to note that the indicated total sugar loss amounted to 30.5% in ten days. Here again we find this loss of about 3% per day for the first ten days.

In 1920, in order to obtain more accurate figures upon which to base estimate of insurance payments in several extensive cane fires a large experiment was conducted at Ewa.

A very uniform section of Field 3A, of slightly over three acres, was selected. This was divided into 48 plots, each plot being large enough to give several car loads of cane, thereby making good samples. There were 12 repetitions of each treatment.

For the purpose of this report a summary only of the results will be given. These were as follows:

* Discarded.

Treatment	Time since Burning	Yield per Acre Cane	Yield per Acre Sugar	% Loss in Weight of Cane	% Loss in Sugar	Brix	Crusher Juice Pol.	Pur.	Q. R.
Block 1	Unburned	86.4*	10.54	.....	.....	18.9	16.32	86.3	8.18
" 2†	0 day	87.2	10.57	.....	.....	18.9	16.23	85.9	8.25
" 3‡	0 day	87.3	10.41	.....	.....	18.6	15.95	85.8	8.37
Block 1	Unburned	92.9*	11.09	.....	.....	18.5	15.96	86.3	8.36
" 2	5th day	81.5	8.96	6.57	15.23	18.6	15.09	81.1	9.13
" 3	5th day	73.9	8.93	15.30	14.22	20.2	16.68	82.6	8.18
Block 1	Unburned	88.4*	10.55	.....	.....	18.3	15.95	87.1	8.34
" 2	10th day	77.3	7.48	11.39	29.23	18.6	14.00	75.3	10.30
" 3	10th day	67.7	7.26	22.45	30.26	21.0	15.69	74.7	9.23
Block 1	Unburned	84.8*	10.09	.....	.....	18.1	15.81	87.4	8.39
" 2	15th day	69.0	5.11	20.89	51.66	18.1	11.75	64.9	13.64
" 3	15th day	61.8	5.33	29.18	48.80	22.1	14.01	63.4	11.60

The above table may be condensed as follows:

LOSSES DUE TO BURNING.

Time since burning	Tons Cane per Acre	Crushed Juice Brix	Pol.	Pur.	Q. R.	Sugar per Acre	% Loss in Weight of Cane	% Loss in Sugar
0 days	87.20	18.9	16.23	85.9	8.25	10.57	.....	.....
5 "	81.45	18.6	15.09	81.1	9.15	8.96	6.57	15.23
10 "	77.25	18.6	14.00	75.3	10.30	7.48	11.39	29.23
15 "	68.97	18.1	11.75	64.9	13.64	5.11	20.29	51.66

The cane was H 109, first ratoons. The cane was mature, but had been recently irrigated. The soil was still somewhat moist. No rain fell during the period of the test. It was very warm with bright sunshine. The cane was burned on July 26.

The losses shown in the above tables would apply particularly to late spring and summer conditions. Earlier in the year when the weather is not so warm and the atmosphere contains more moisture it is possible that the losses would be somewhat less, especially losses in cane weight.

During 1920, twenty-three tests were conducted on four plantations, these were Paauhau, Onomea, Kilauea and Hawi. These tests were conducted under the auspices of the Hawaiian Chemists' Association, Mr. Raymond Elliott was chairman of the committee.

In summarizing the results Mr. Elliott reported in part as follows:

The cane loses weight from the time it is cut until it is ground, although the conditions vary. When the weather is hot and with a breeze the loss in weight is at the maximum, whereas, when the atmosphere is saturated with moisture, the loss is lessened.

The difference between burned and unburned cane is distinctly seen at Paauhau and Kilauea.

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* 5% off for trash.

† Block 2 Cane burned and allowed to stand until harvested.

‡ Block 3 Cane burned and cut at once, and allowed to lie on field until harvested.

The burned cane deteriorates faster than unburned cane, practically under the same condition, with rainfall very slight in both places, for the first three days.

Taking the average after cutting for burned cane, the loss for the first day is 3.8%, representing five tests from three districts, variety Yellow Caledonia. For unburned cane, the loss for the first day is 2.52%, representing six tests from four districts, variety Yellow Caledonia.

For the second and third days the losses for burned cane are 8.88% and 9.67% as against unburned, which are 5.67% and 6.49% respectively.

The ratios in favor of not burning are: first day, 1.51; second day, 1.57; and the third day, 1.49.

Following are Tables 1 and 2, showing the averages for burned and unburned cane:

TABLE NO. 1—BURNED CANE. VARIETY: YELLOW CALEDONIA.
% LOSS IN SUGAR.

		No. of Days after Cutting							
Plantation	No. of Tests	1	2	3	4	5	6	7	8
Paauhau	1	.46	8.16	18.77	16.93	13.87	18.09	18.04	19.03
Kilauea	1	*2.30	.....	* 1.8	2.6	9.6	.....	.....	.....
Kilauea	3	5.76	18.10	18.51	32.02	.....	.....	.....	.....
Kilauea	4	8.49	8.93	7.96	7.29	12.62	.....	17.20	.....
Hawi	1	6.6	.3	4.9	3.3	* 1.5	19.9	* 3.0	28.6
Average	10	3.80	8.88	9.67	12.43	8.63	19.00	16.12	23.82

TABLE NO. 2—UNBURNED CANE. VARIETY: YELLOW CALEDONIA.
% LOSS IN SUGAR.

		No. of Days after Cutting							
Plantation	No. of Tests	1	2	3	4	5	6	7	8
Paauhau	3	2.22	3.70	5.25	12.58	19.18	21.27	28.05	30.02
Onomea	1	1.20	8.20	7.20	8.0	7.5	4.8	10.3	9.2
Onomea	2	2.10	2.90	* .5	8.8	3.1	3.8	1.5	3.2
Onomea	3	*4.00	.9	2.4	4.4	8.1	8.9	12.8	16.8
Kilauea	2	5.00	4.8	5.7	.....	12.6	.....	.....	.....
Hawi	2	8.6	13.5	18.9	37.6	36.1	48.2	34.2	43.6
Average	13	2.52	5.67	6.49	14.28	14.43	17.39	17.37	20.56

In these tests small bundles of cane only were used. It is impossible to handle small bundles of cane and obtain concordant results. But by averaging the results of all the tests we believe we obtain some information as to what to expect under general conditions.

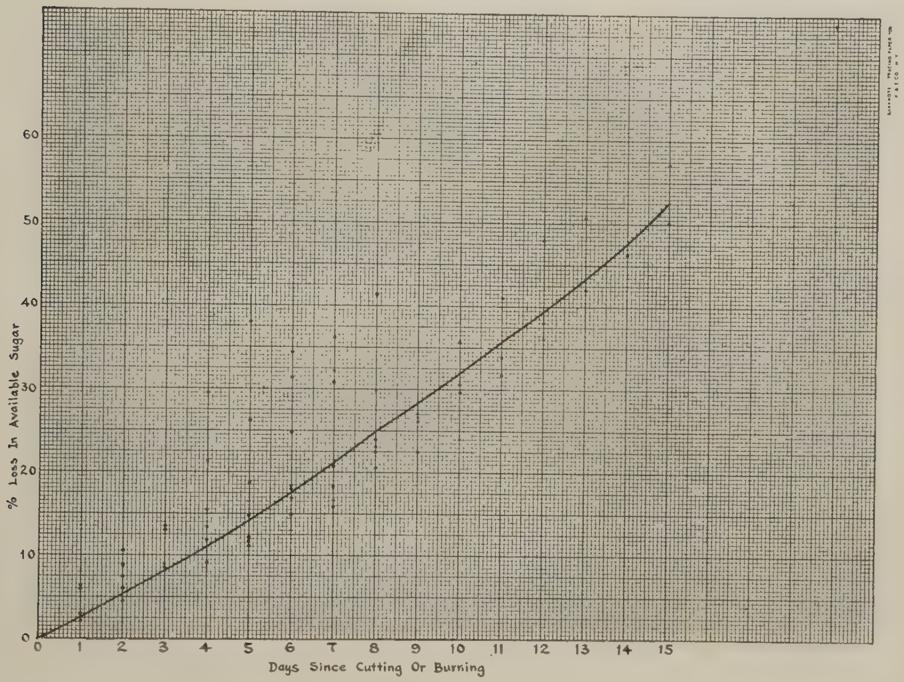
The average losses are seen to be about 21 to 24% in eight days, or about 3% a day.

For the sake of convenience the summaries of the local tests are brought together in the following tabulation:

N. B. Onomea's cane assumed as unburned.
* Plus values.

Plantation	Conducted by	No. of Tests	Days Old 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
O. S. Co.	P. Messchaert	3	2.3	8.6	8.9	9.1	11.1	16.9	18.3	23.2	22.6	24.2	31.8	36.0	....	....	....
Makiki Plot	Verret & McAllep	3	...	5.8	13.5	21.3	26.3	31.4	36.4	41.4	....	....	....	....	....	....	....
Hutch. Sugar Plant.	V. Marcallino	1	...	....	....	....	11.7	14.9	15.9	20.4	26.6	35.8	41.0	47.9	50.6	....	57.2
H. S. Co.		1	6.0	10.4	....	29.5	38.2	34.4	32.2	....	....	....	....	....	....	....	....
Paauhau	Westly	2	2.4	4.4	13.0	15.5	18.8	24.8	30.8	29.9	26.2	30.5	....	....	....	....	....
Ewa Plantation Co.	Verret	1	2.9	5.9	8.8	11.8	14.7	17.7	20.7	23.7	26.7	29.7	33.8	37.9	42.0	46.1	50.2
Hawn. Chemists' Assn.	Raymond Elliott, Chairman	23	3.2	7.3	8.1	13.4	11.5	18.2	16.7	22.4	....	....	....	....	....	....	....

In the accompanying illustration the figures in the above table were plotted on coordinate paper and an attempt was made to draw a curve representing the average results obtained in these different tests.



It will be seen that this curve follows the Ewa results very closely.

It would therefore seem that for average conditions, losses of the nature of those obtained in the Ewa test are to be expected from delays in milling after cutting or burning.

We hope to be able to do more work along these lines. Especially for the first two to four days after burning, as this is the period in which most burned cane is now handled.

Irrigation Investigations at Waimanalo

By G. R. Stewart.

Purpose of the Experiment.

The experiment was undertaken at the request of Messrs. C. Brewer & Company, to try and determine the economic limits in the use of irrigation water at Waimanalo. An additional water supply had been developed by the plantation and further work was contemplated. Information was therefore desired as to the maximum amount of irrigation water which the plantation could use and produce an adequate return in the production of additional sugar.

Methods of the Investigation and Organization of the Work.

The following plan was developed in conference with Mr. Chalmers, Manager, Waimanalo Sugar Company, and Mr. Agee, Director of the Station. Large plots of about an acre or more were to be chosen in several typical fields. These plots were to receive complete irrigation from the time of starting the experiment up to the time of ripening the cane before harvesting. These extra irrigated areas were to be compared to similar plots in the same fields, which received the ordinary plantation treatment.

Three such experiments were started. One experiment was laid out in Field 8, and another in Field 22, in cane which was about a year old. A third experiment was located in Field 15 where young plant cane was just up. In addition four observation plots were chosen in Fields 1, 3, 12 and 14, where the cane was to receive only the usual plantation treatment. This was for the purpose of studying the effect of variation in the growing conditions, in different portions of the plantation.

The following work was carried out on the three comparison experiments:

1. Measurements were made of the irrigation water applied to the extra irrigated plots and the crop cane. V-notched weirs of standard type were employed in this work.

2. Determinations were made of the moisture content of the soil in the extra irrigated plots before and after irrigation. In the ordinary crop cane moisture determinations were made between irrigation periods, in addition, to follow the moisture changes during these longer periods of time. The method of making the determinations is briefly as follows: Four to six or more duplicate borings were made in each plot at every period of sampling; the borings being spaced 30 to 60 feet apart. The borings were carried to a depth of six feet and samples from the boring of each individual foot were analyzed and the results for each foot then averaged.

3. Weekly measurements were made of the growth of the cane in all plots, irrigated and unirrigated. The system followed was that used by the agriculturists of this Station. In each plot in the areas to receive extra irrigation, and in similar locations in the crop cane, four to six typical stools of cane were chosen. The number of shoots and stalks were counted and tags attached to each stalk for future identification. Two average stalks in each stool were chosen and a copper wire ring was fixed near the base of the stalk, and measurement was made from the node near this ring to the base of the last visible dewlap. Later in the work another copper ring was placed higher up on the stem to facilitate the work of measurement.

4. The above observations were to be correlated with the regular mean temperature readings which are made by the plantation weather station.

Results.

The work was started by the members of the Chemical Department, but was soon taken over by Mr. William Weinrich for Waimanalo Sugar Company. We have continued to cooperate in the measurement of the growth and in making the moisture determinations. In briefly summarizing the results from the commencement of the work on June 26 to November 30, I desire to emphasize the fact that this is only a preliminary report. It appeared desirable to bring together the data so far obtained, so that the results might be available to those especially interested in this problem.

Water Measurement Results.

The results of the measurement of the irrigation water in all three experiments are given in Table I. At the beginning of our work the soils in all three fields were very dry. We therefore directed the irrigators to put on what they considered a full irrigation with one man's water, each week. As soon as we were able to start accurate measurements it was found that the amounts were radically different in each case.

In Field 8 the average irrigation was 4.5 to 5.0 acre inches. We were soon able to extend the period between irrigations in this field, from one to two weeks. The first few irrigations had to be made without measuring weirs, so the figure in such cases is the average of the later applications and is enclosed in parenthesis.

In Field 22 the irrigators were applying about 3.3 acre inches at an irrigation, so we continued the weekly period of irrigation throughout the experiment.

TABLE I.

SUMMARY OF IRRIGATION APPLIED TO EXTRA IRRIGATED AND CROP CANE.

Field 8			Field 22			Field 15, Plant Cane			
Date of Irrigation......	Extra Irrigation Cane Acre Inches......	Crop Cane Acre Inches..........	Date of Irrigation......	Extra Irrigation Cane...	Crop Cane...........	Date of Irrigation......	Extra Irrigation Cane...	1 Month Irrigation Period............	Crop Cane...........
June 30...	(4.83)	....	July 1...	(3.30)	....	July 5...	(1.51)	....	....
July 20...	(4.83)	(4.29)	July 8...	(3.30)	....	July 14...	(1.51)	....	....
July 28...	(4.83)	....	July 14...	(3.30)	....	July 21...	(1.05)	....	....
Aug. 10...	(4.83)	(4.29)	July 21...	(3.30)	....	July 28...	(2.21)	....	....
Aug. 24...	(2.76)	....	Aug. 4...	3.98	4.84	Aug. 4...	1.50	....	....
Sept. 7...	5.42	5.04	Aug. 18...	3.22	....	Aug. 18...	1.40	....	....
Sept. 21...	4.82	....	Aug. 25...	4.31	....	Aug. 25...	1.53	2.00	....
Oct. 4...	5.33	....	Sept. 1...	3.45	....	Sept. 1...	1.45	....	1.89
Oct. 18...	5.91	....	Sept. 8...	3.47	6.80	Sept. 8...	1.53	....	....
Nov. 2...	4.81	3.55	Sept. 15...	2.76	....	Sept. 15...	1.23	....	....
Nov. 29...	4.76	....	Sept. 23...	2.97	....	Sept. 30...	1.81	2.56	....
			Sept. 30...	3.97	4.98	Oct. 6...	1.74	....	....
			Oct. 6...	3.10	....	Oct. 13...	1.76	....	....
			Oct. 13...	3.16	....	Oct. 20...	1.90	....	....
			Oct. 20...	3.33	....	Oct. 27...	1.02	2.04	....
			Nov. 3...	2.46	2.76	Nov. 3...	1.42	....	2.20
			Nov. 10...	2.73	....	Nov. 10...	2.07	....	....
	53.13	17.17		56.11	19.38		25.64		4.09
	8.08	8.08		8.08	8.08		8.08		8.08
	61.21	25.25		64.19	27.46		33.72		12.17

One Month Irrigation experiment not started till August, so Irrigation is not totaled.

It will be seen that the total amounts applied to both fields in the extra irrigated and crop cane are practically the same. The extra irrigated area received practically three times the amount of water given to the crop cane.

In Field 15 the average irrigation in young cane was found to be 1.5 to 2.0 acre inches. We continued to apply this amount each week and found this kept the soil close to the optimum moisture content. In this field, Mr. Weinrich found it advisable to install another comparison after the work was under way. This was to apply irrigation regularly once each month. The results of these applications are not totaled as it would not be comparable with the extra irrigated and crop treatments. Here it is seen that the extra irrigated cane received approximately six times as much irrigation as the crop cane.

Owing to the acute water shortage during the past season, which was intensified by the necessity of putting in so much plant cane, the irrigation rounds were

rather irregular in the ordinary plantations fields. We were therefore not able to get complete irrigation data on the applications to the crop cane experiments in Fields 1, 3, 12 and 14. Our work on these four plots has been especially concerned with soil mixture and growth studies.

Moisture Determinations.

For simplicity of observation the moisture data is presented in the form of graphs, in which the moisture of the extra irrigated plots is compared with the moisture in the soil of the crop cane area. The moisture results are all expressed as per cent of dry weight of soil, as is usual in irrigation water studies. On this basis the optimum moisture percentage in the Waimanalo soils was found to range from 45 to 55%, though fair growth may take place if the content occasionally drops to 40%. A moisture content continuously below 40%, is certain to retard the growth of the crop.

Chart I gives the moisture results for Field 8. The curves show that the moisture in the extra irrigated plot was kept well up towards the optimum. The soil of the crop cane plot was notably lower at many periods. This was especially true in the top two feet of soil, but some differences prevailed at the lower levels.

Chart II gives the moisture results for Field 22, which show the same differences between the extra irrigated and crop cane.

Chart III gives the results for Field 15. Here the differences are especially striking in the first and second feet of soil, where this young cane was largely feeding.

Chart IV gives the results for three of the drier fields, Nos. 1, 12 and 14. Here the range of moisture lay far below the optimum content, even down into the fifth and sixth foot of soil. The curves for these lower depths are discontinuous, owing to the presence of rocks in some sample holes.

Measurements of Growth.

Our first plan was to estimate growth in two ways, by the elongation of the sticks, and by a count of the development and size of new shoots formed after full irrigation was applied. These two estimations were carried out but we observed toward the close of the work covered in this report, that the elongation of cane in the drier fields after a rain or irrigation did not express the growth correctly. A considerable elongation frequently took place, but the size of the stick was greatly inferior to sticks which were making about the same growth with regular water. Mr. Weinrich therefore carried out a very painstaking measurement of the volume of the sticks in two typical rows of cane in Field 15. One of these was in the extra irrigated and the other in the regular crop cane. A comparison of the results brings out several interesting differences. A brief summary of results of our elongation studies is given in Table II. These tables give the average length of the measured sticks of cane at the beginning of the experiment and on November 30. The increase is given in feet and the gain due to irrigation is calculated.

CHART I
MOISTURE DETERMINATIONS
FIELD 8.

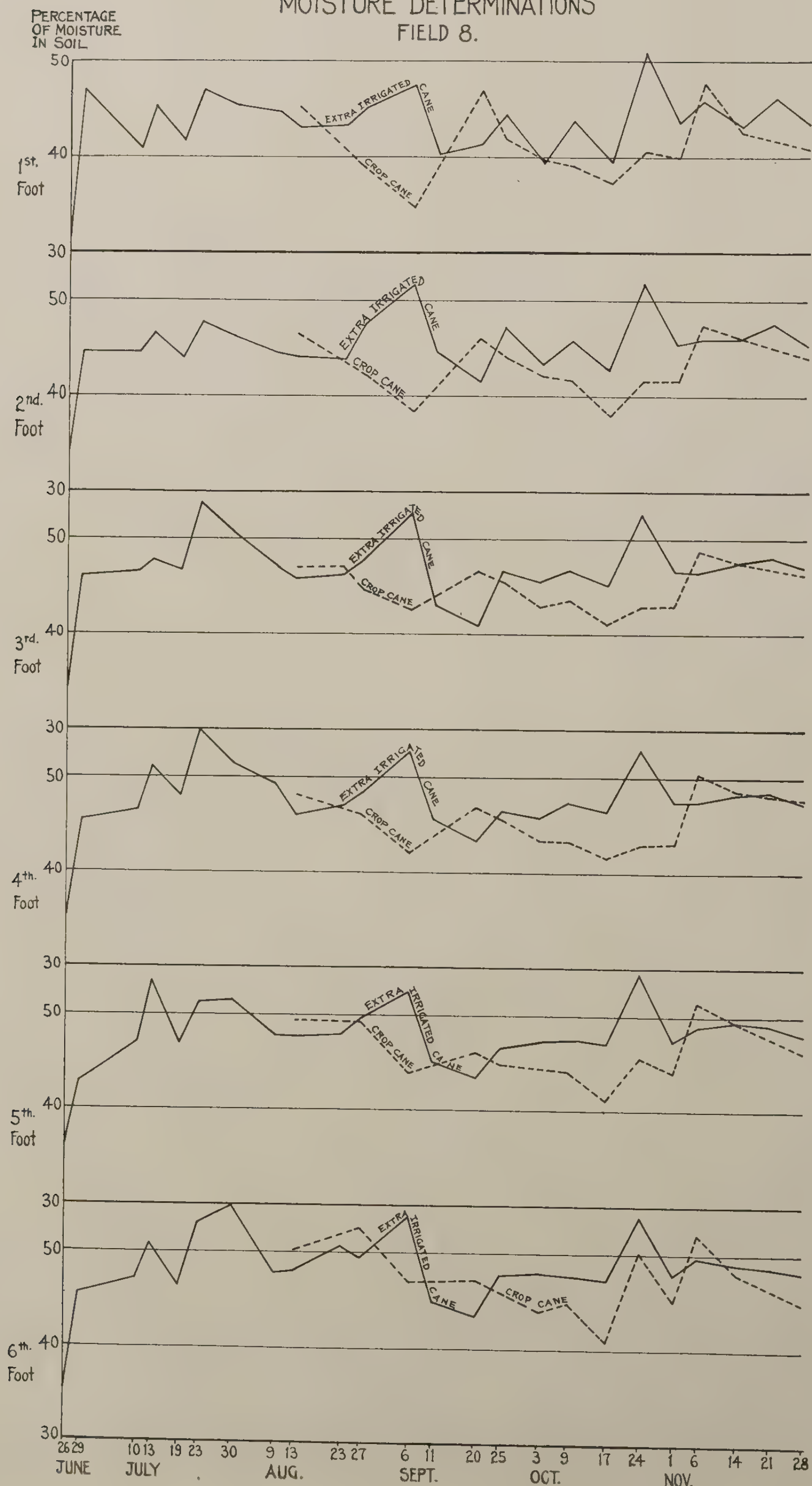


CHART II
MOISTURE DETERMINATIONS
FIELD 22.

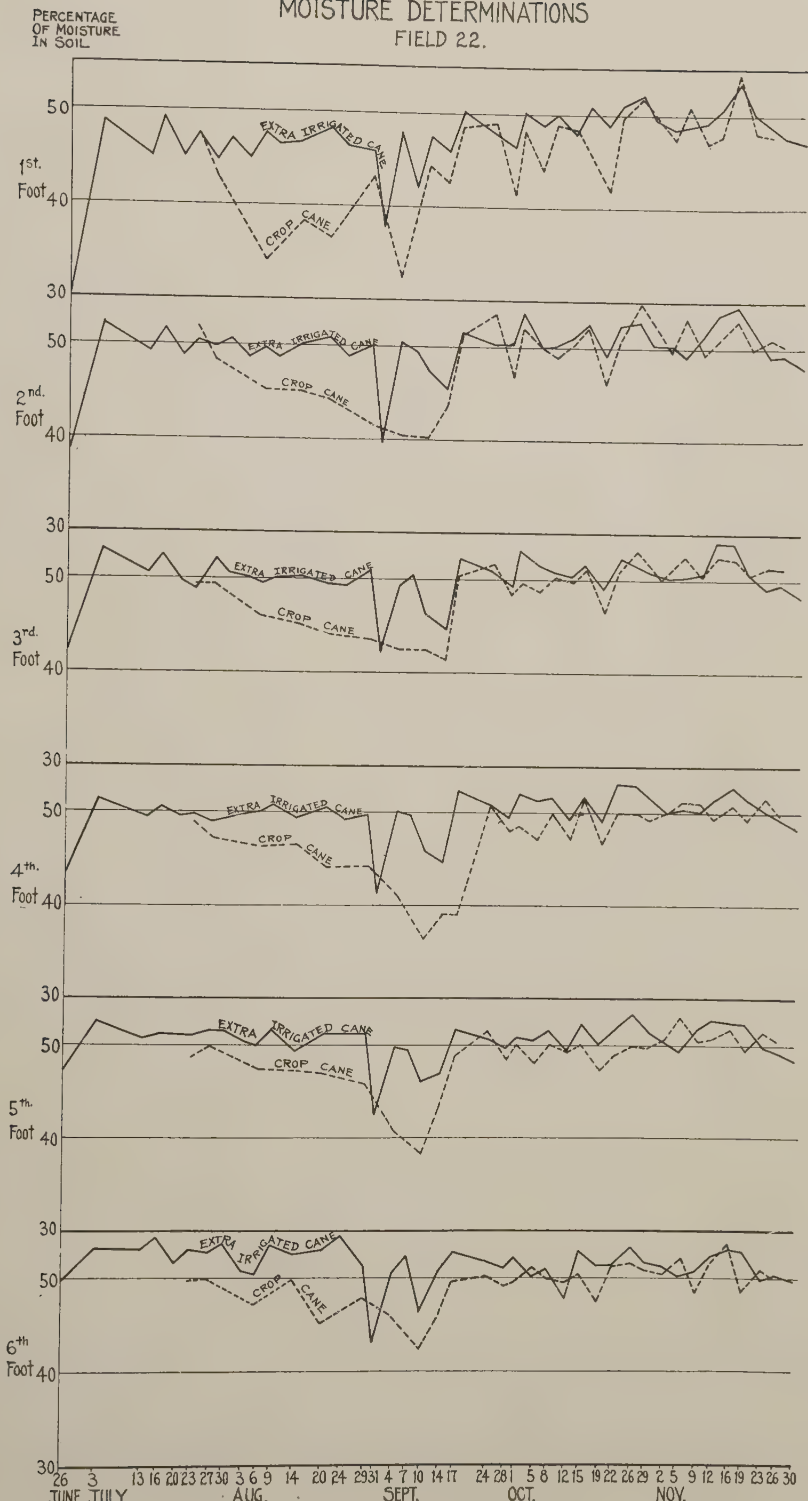


CHART III
MOISTURE DETERMINATIONS
FIELD 15

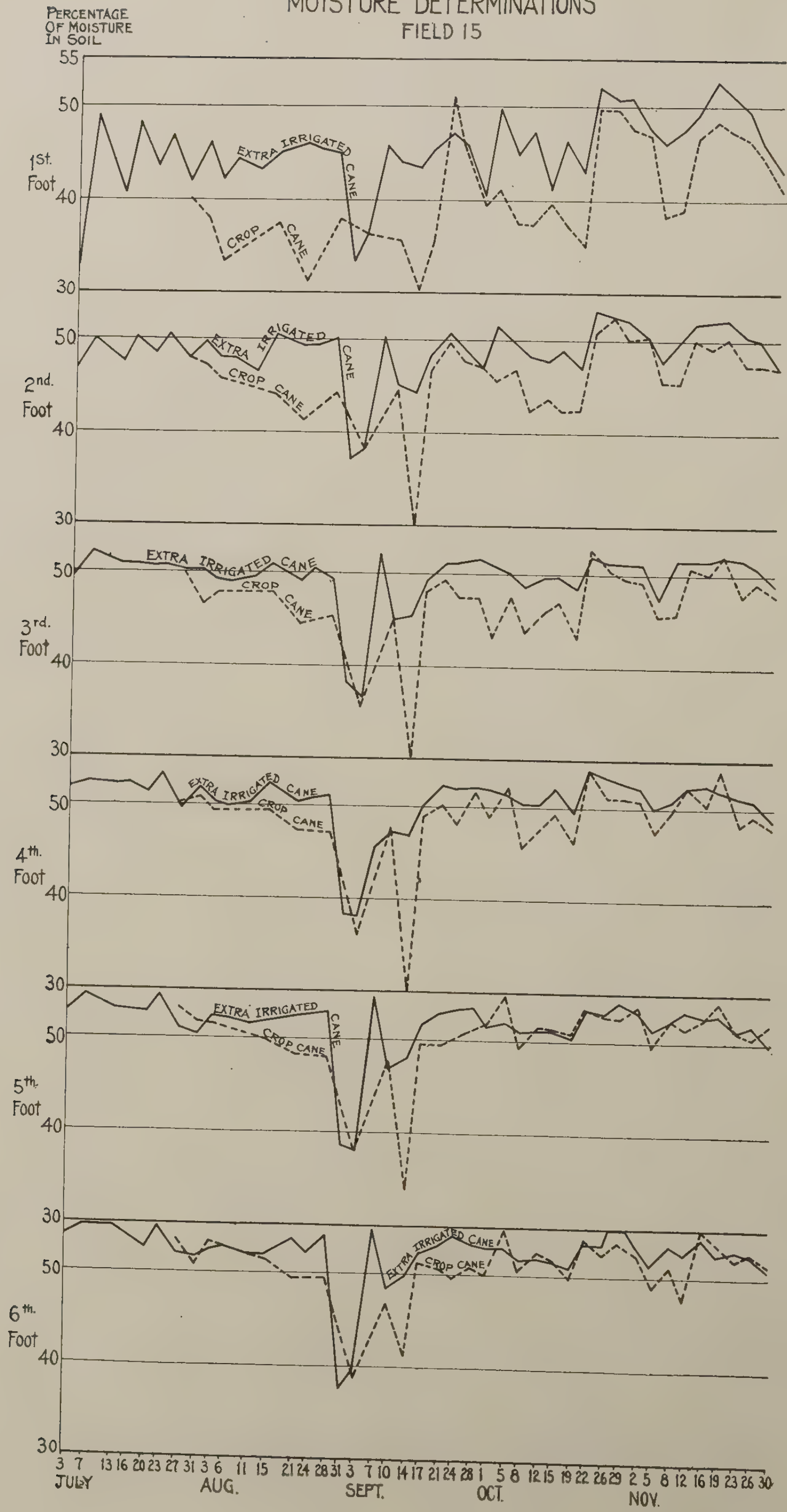


CHART IV

MOISTURE DETERMINATIONS

FIELDS 1, 12 & 14.

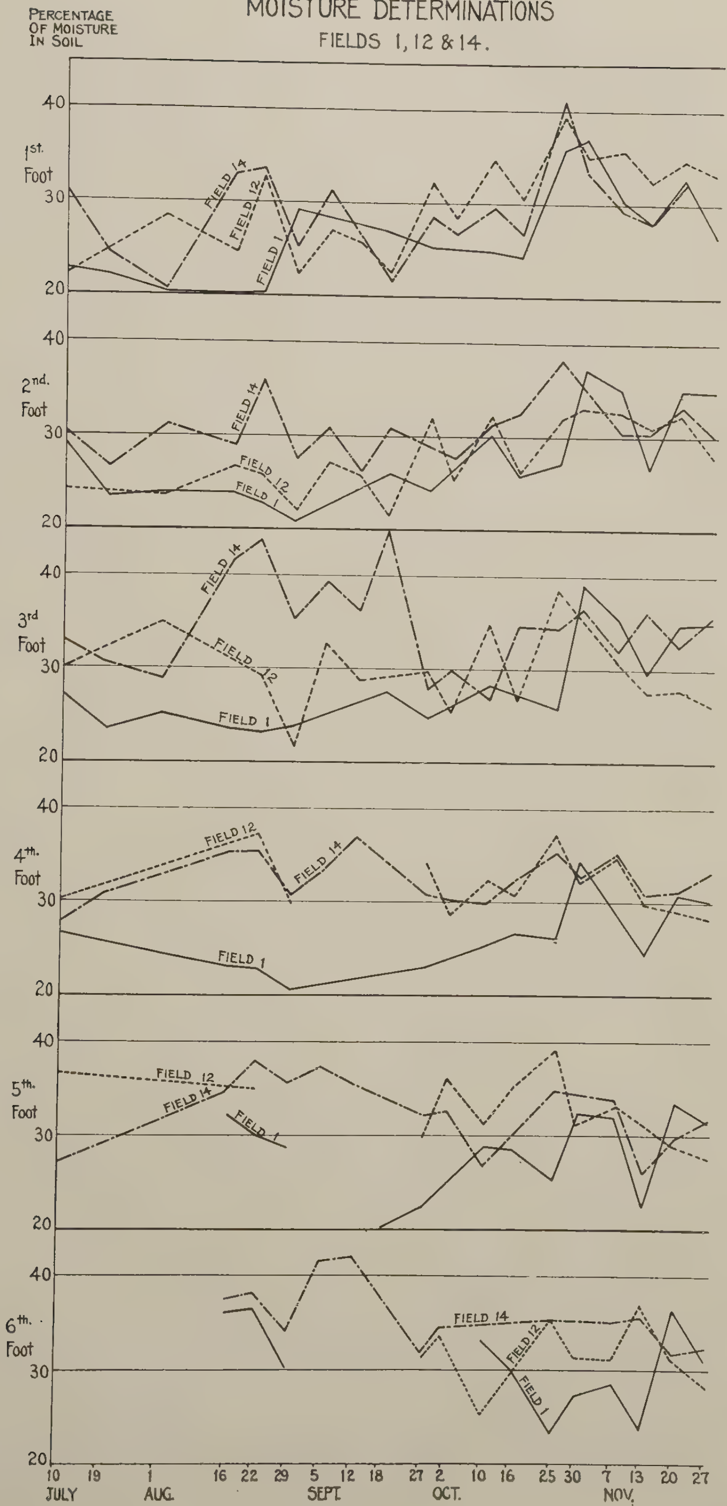


TABLE II.

SUMMARY OF GROWTH MEASUREMENTS.—ELONGATION OF STICKS OF CANE.

Field No.	Treatment	Average Length at start Feet	Average Length Nov. 28 Feet	Increase Feet	Gain due to Irrigation Feet
8	Extra Irrigation...... 255 lbs. N.	8.17	17.10	8.93	3.40
	Extra Irrigation...... 215 lbs. N.	7.85	16.38	8.53	3.00
	Extra Irrigation...... 175 lbs. N.	7.83	16.75	8.92	3.39
	Crop Cane	7.12	12.65	5.53	....
22	Extra Irrigation......	6.41	14.33	7.91	2.69
	Crop Cane	6.59	11.81	5.22	....
15	Extra Irrigation......	0.19	6.57	6.38	3.81
	1 Month Irrigation...	0.025	3.20	3.18	(Started .61(1 month (late
	Crop Cane	0.01	2.58	2.57	....
1	Crop Cane	5.53	9.74	4.21	....
3	Crop Cane	4.31	7.94	3.63	....
12	Crop Cane	4.08	6.48	2.40	....
14	Crop Cane	4.80	7.93	3.13	....

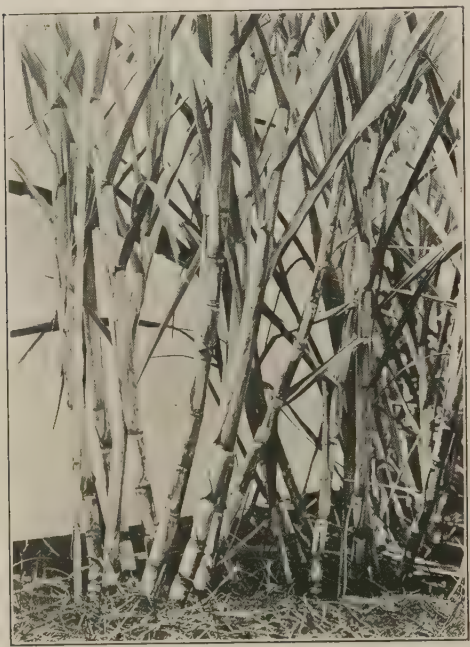
In the extra irrigated cane in Field 15 it is seen that this plot made 2.5 times as much increase in growth as did the ordinary crop cane. In Mr. Weinrich's measurements he found in five watercourses of the extra irrigated cane, 375 stalks with measurable sticks. In the same distance in the crop cane there were 81 sticks. The extra irrigated cane in this length of row contained 5.24 cubic feet of stick which would be harvestable cane. The crop cane contained 0.66 cubic foot or just about one-eighth the volume present in the extra irrigated. Whether this difference persists will depend on the growth made this winter, when each plot is adequately supplied with water by rainfall. Further evidence of the present difference in the growth of the plant cane in Field 15, is given by a series of five photographs, taken by the writer. These show the extra irrigated cane, the 1 month's irrigated cane, and the crop cane. Two close up views of the stick development of the extra irrigated and crop cane are also included. Besides the development of stick shown in these views it may be pointed out that the extra irrigated cane is completely closed in and practically free from weeds. The crop cane is still very open so that weed growth will be heavy during the winter months.

The detailed results of the elongation measurements are given in a series of graphs numbered 5-13 inclusive. These graphs are plotted so as to show the growth in two different ways, one of these represents the average weekly growth and the other the total mean growth during the period of the experiment. In Chart V of the total growth of the plots in Field 8, it will be seen that we had applied extra irrigation to three groups of plots in the amounts of nitrogen

These views show the extra irrigated cane (left), the one month irrigated cane (center), and cane irrigated at variable intervals as per field practice.

experiment conducted in this field. The three treatments show little difference in response, though it is not certain this would have been the case had full irrigation been supplied the first season. The cane in Field 8 was growing better than in Field 22 at the beginning of the experiment and I believe this explains the larger increase from the same total increase in irrigation water.

The periods of small weekly growth in the various plots of crop cane correspond to the drier periods between irrigations.



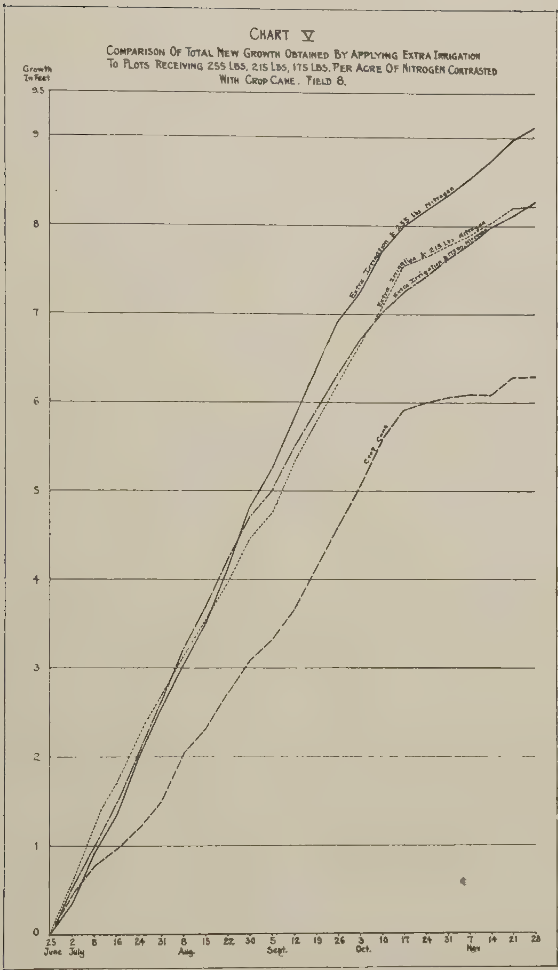
These views show the stick development of extra irrigated cane compared with normal field practice, which utilizes a small amount of water over a wide area.

Growth Development of New Shoots.

A careful count was made of all shoots present in the cane of the various plots of large cane at the beginning and close of the experiment. Weekly counts were made of the development of shoots in the young plant cane in Field 15.

In the older cane in Field 8, no new shoots developed during the period of our study. All the increased growth went into the stalks already present. In Field 22 the stand of cane was not so thick at the commencement of the experiment. In this field one-third of the stools measured had developed one shoot four to five feet high. This emphasizes the desirability of getting a good stand in the first season's growth, because these late shoots are not likely to be any benefit to this cane owing to their probable immaturity at harvest. Had full irrigation been applied earlier it is possible that second season shoots might have been a desirable thing. This is a point which will require further observation in the future.

In the young plant cane in Field 15, there was a notable difference in the development of new shoots in the crop cane and the extra irrigated area. We



made a weekly count of the increase in several watercourses of average length. In the crop cane the increase was slow until showery weather came in October. At the start the crop cane had 43 shoots per watercourse, which by October 10 had increased to 65. At this same date the full irrigation had increased from 41 to 92 shoots. Since this date the crop cane has continued to form new shoots because of the open type of growth. The number of shoots in the extra irrigated cane has remained constant, all new growth going into the sticks which were formed. There is no question as to relative volume in the sticks present in the two different areas. The relative economy in production of cane cannot be judged till we have next season's figures for comparison.

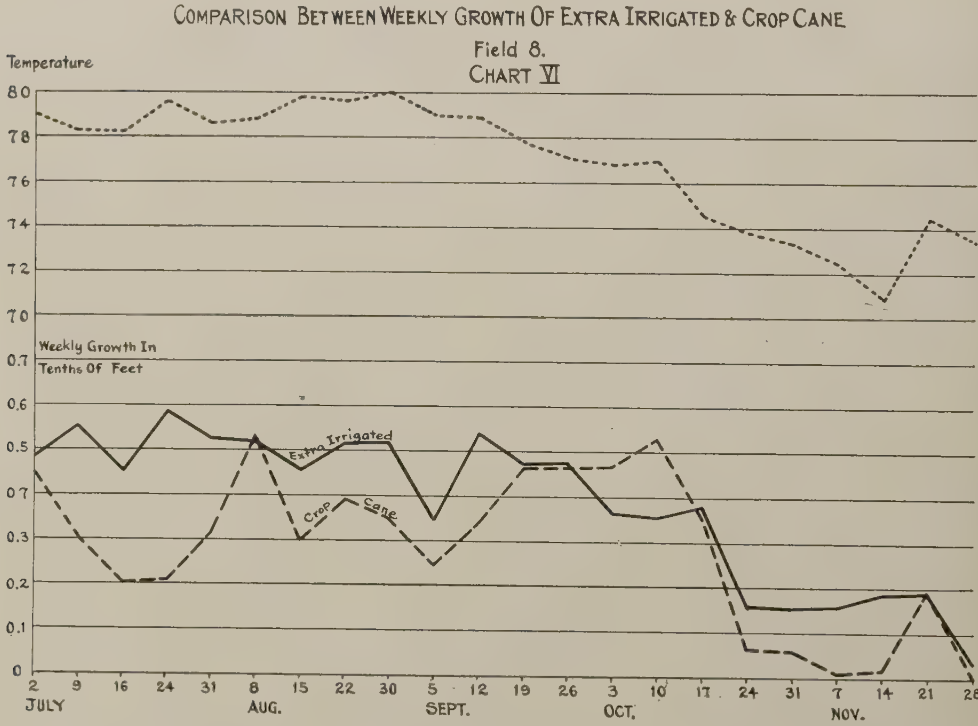
Tasseling.

We have observed some notable differences in the development of tassels in the plots in Field 8. This field as previously noted was growing more vigorously than any other cane on the plantation where we started our work. Only a small per cent of the sticks measured in the extra irrigated plots have tasseled, while

nearly all those under observation in the crop cane have developed arrows. The differences have not been quite so striking in Field 22, but here also there is less tasseling in the fully irrigated cane.

Water Distribution.

In studying the growth and irrigation of the various areas under observation, I have noted that in the attempt to make use of all possible water, cane has been planted in many fields in part of the level ditches and along the main irrigation ditches. After observing the distribution of water in the fields I do not feel that this plan has been a success. Having cane in some level ditches has tended to make the irrigation uneven. Such cane is also raised without its full nitrogen supply and so makes cane growth by the use of a greatly increased water consumption, compared to ordinary cane in the fields.



The ideal field ditch should be absolutely impervious. Cane roots growing in or near the ditch increase the percolation and seepage because the roots open up the soil and cause minute drainage channels.

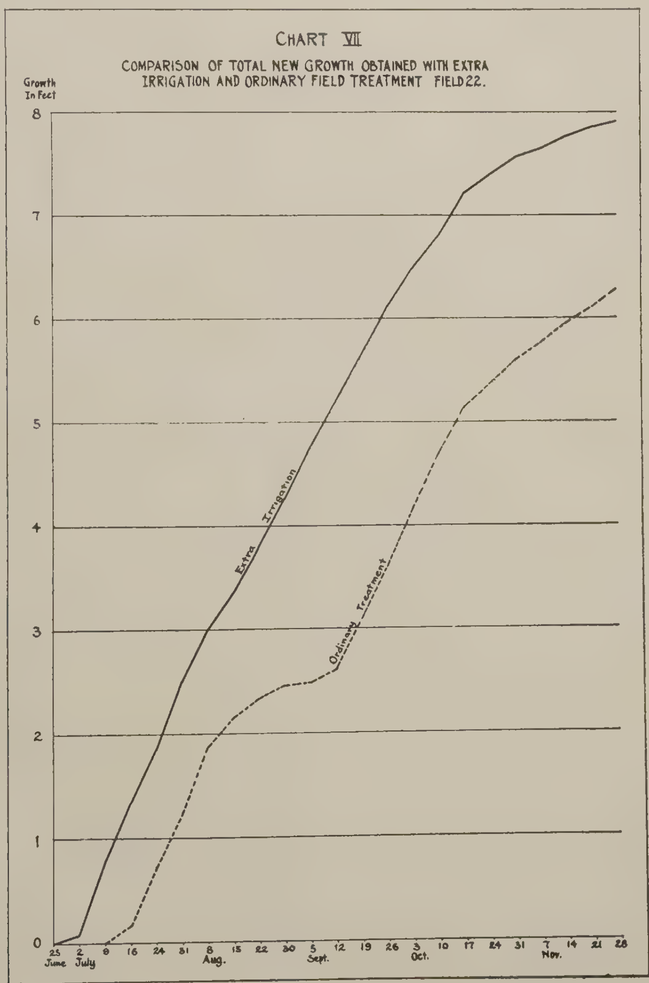
Effect of Temperature.

In the accompanying charts, to show the total seasonal growth, the temperature has been plotted upon the upper portion of certain charts. The general showing up of growth late in the season is clearly shown to be influenced by the fall in temperature. Up to November 30, it is worthy of note that the young cane has

kept up a larger per cent of its growth than the larger cane. Nearly all of the large cane has made a notable decrease which in some cases almost amounts to a cessation of growth.

Fertilization.

There has been no change in the fertilization of any of the large cane under observation. Field 22 has all received 175 lbs. nitrogen per acre. Field 8 has received varying amounts of nitrogen from 255-175 lbs. in the extra irrigated plots, while the crop cane has received 175 lbs.

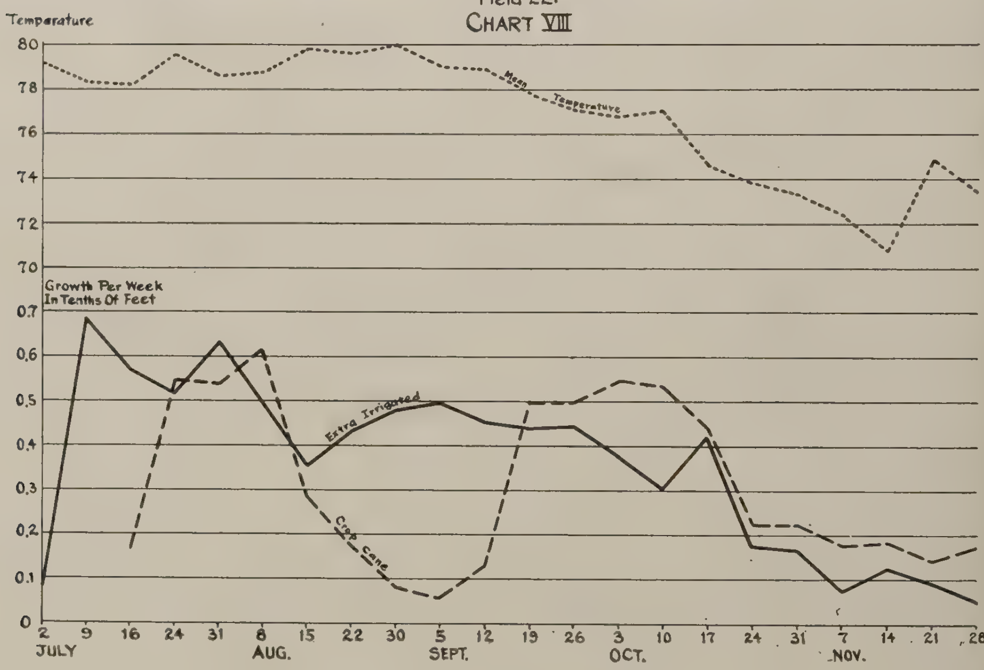


In Field 15, the extra irrigated cane received 100 lbs. nitrogen per acre in August and 1,000 lbs. per acre of mixed fertilizer supplying 120 lbs. nitrogen in November. The crop cane received 1,000 lbs. mixed fertilizer in late October.

TENTATIVE DEDUCTIONS FROM THE ABOVE RESULTS.—IRRIGATION AND SOIL MOISTURE.

The results obtained from these two observations warrant us in stating that it will take approximately 2 acre inches per weekly irrigation, measured into the level ditches for full continuous growth with young plant cane. Second season irrigation will require 4.5 to 5 acre inches applied every two weeks for the best results. Improved results would be obtained on both crops if regular irrigations were possible even once per month.

COMPARISON BETWEEN WEEKLY GROWTH OF EXTRA IRRIGATED & CROP CANE
Field 22.
CHART VIII



GROWTH.

The growth figures show several things:

1. The importance of early irrigation and a full stand in young plant cane.

2. Continuous growth develops a larger stick and a notable difference in the response to irrigation.

3. Cane growth is largely affected by three things: water, fertilization and temperature. The present fertilization and temperature at Waimanalo are adequate for excellent crops, but the water supply is entirely inadequate.

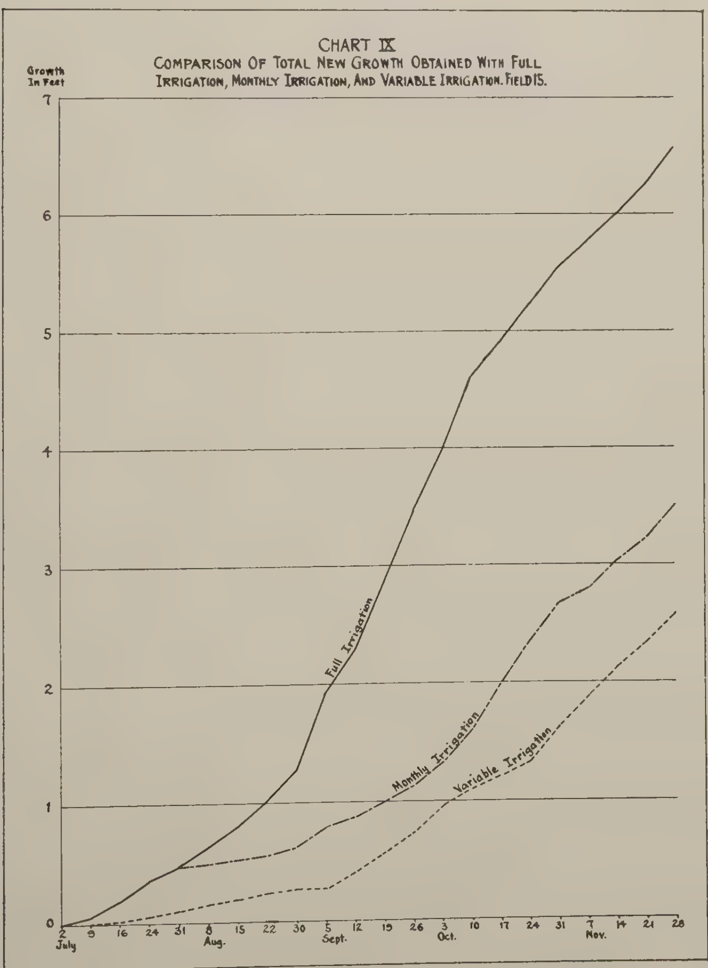
Calculation of Probable Water Requirements at Waimanalo.—Full Irrigation.

In answer to the inquiry of Messrs. C. Brewer & Company as to the amount of water which can be economically used at Waimanalo, I desire to submit the following calculation:

Total area in Cane................................	2,700 Acres
Unirrigated	300 Acres
Irrigated	2,400

This area will be divided into two average crops on January 1.

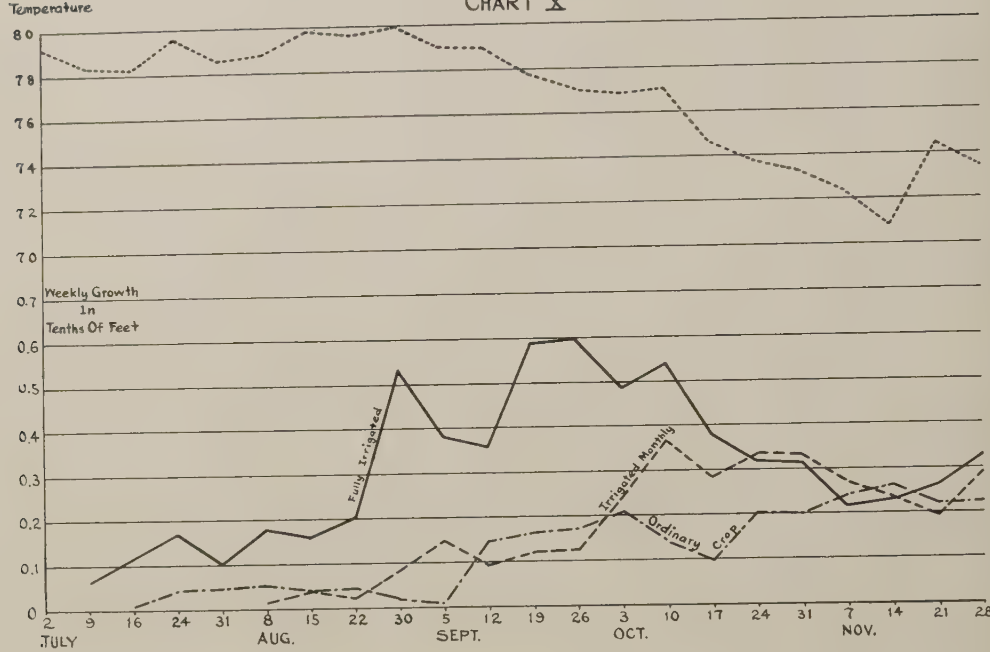
The harvesting cane...................1,400 acres	150 acres unirrigated	1,250 acres irrigated
Young plant cane and ratoons...........1,300 acres	150 acres unirrigated	1,150 acres irrigated



Comparison Of Weekly Growth Made By Cane Fully Irrigated, Irrigated Monthly & Ordinary Crop Cane

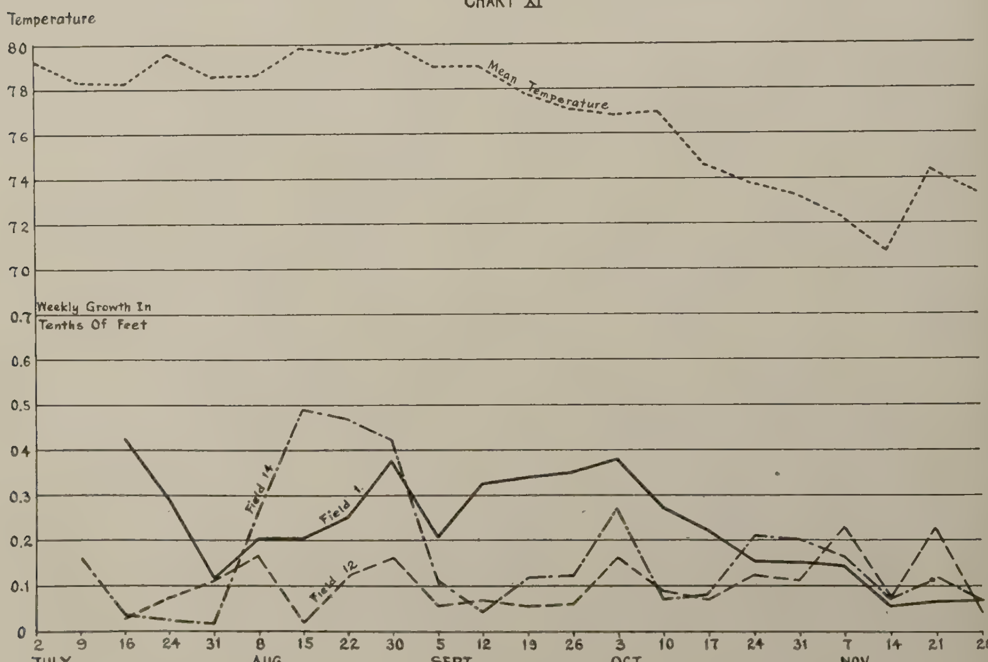
Field 15.

CHART X



Comparison Of Weekly Growth Obtained With Ordinary Plantation Treatment In Fields 1, 12 & 14

CHART XI



We will assume that harvesting starts January 1 and will be complete about the middle of July. This means that approximately 200 acres of irrigated cane will be harvested each month. This cane ready for harvest will not require irrigation, except that the last fields to be taken off in May, June and July may require one or two rounds of water. This water will be available as the full irrigation demand will not be made before July. We shall therefore omit the harvesting crop from our calculations.

The young plant cane and young ratoons will receive 2 acre inches of water per week after March 1, and the second season cane will receive 4.5 to 5 acre inches every 14 days from March 1 to November 15. The daily demand for this water is given in the following table:

FULL IRRIGATION, ANNUAL SCHEDULE.

Date	Cane Subject to Irrigation Second Season Cane	Young Cane	Total Area to be Irrigated	Irrigation Second Season Cane Gals. per Day	Irrigation Young Cane Gals. per Day	Total Gallons per Day
Jan. 1.........	1,150	0	....	....	....	....
Feb. 1.........	1,150	200	....	....	....	....
Mar. 1.........	1,150	400	1,550	10,037,282	3,103,314	13,140,596
April 1........	1,150	600	1,750	10,037,282	4,654,971	14,692,253
May 1.........	1,150	800	1,950	10,037,282	6,206,628	16,243,910
June 1.........	1,150	1,000	2,150	10,037,282	7,758,285	17,795,567
July 15........	1,150	1,200	2,350	10,037,282	....	....
Aug. 1.........	1,150	1,250	2,400	10,037,282	9,697,856	19,735,138
Sept. 1	1,150	1,250	2,400	10,037,282	9,697,856	19,735,138
Oct. 1	1,150	1,250	2,400	10,037,282	9,697,856	19,735,138
Nov. 1 to 15....	1,150	1,250	2,400	10,037,282	9,697,856	19,735,138

If we allow 30% for transmission losses in ditches, the final figure will be 25,600,000 gallons per day, required for reasonably full irrigation. A conservative estimate will be 25 to 30 million gallons of irrigation water per day.

MINIMUM WATER REQUIREMENT FOR REGULAR ROUNDS OF IRRIGATION.

Total areas as given above. One thousand two hundred fifty acres of mature irrigation cane, ready for harvest from January to July 15. This cane will receive no irrigation.

Irrigation Scheme—1,150 acres of cane, 6 to 12 months old which is to receive 4.5 to 5 inches of water every 30 days.

The young ratoons to receive 2 irrigations during the first season, each irrigation to be from 4.5 to 5 acre inches. Average area in plant cane will be about 250 acres to be started by April 1. This plant cane will receive 2 acre inches of water every 2 weeks till November 15.

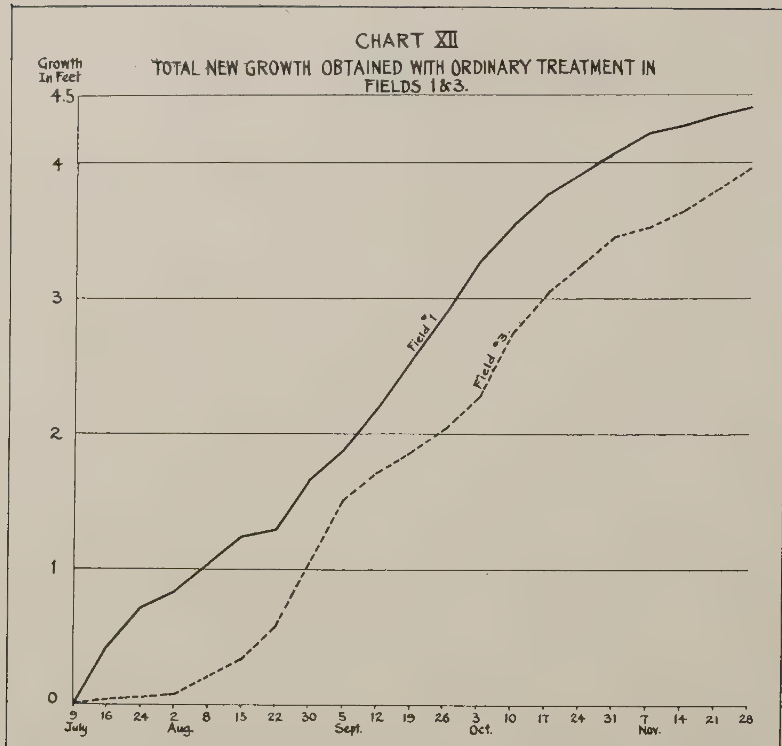


CHART XII
TOTAL NEW GROWTH OBTAINED WITH ORDINARY TREATMENT IN FIELDS 1 & 3.
Growth In Feet
4.5
4
3
2
1
0
Field #1
Field #3
9 July
16
24
2 Aug.
8
15
22
30
5 Sept.
12
19
26
3 Oct.
10
17
24
31
7 Nov.
14
21
28

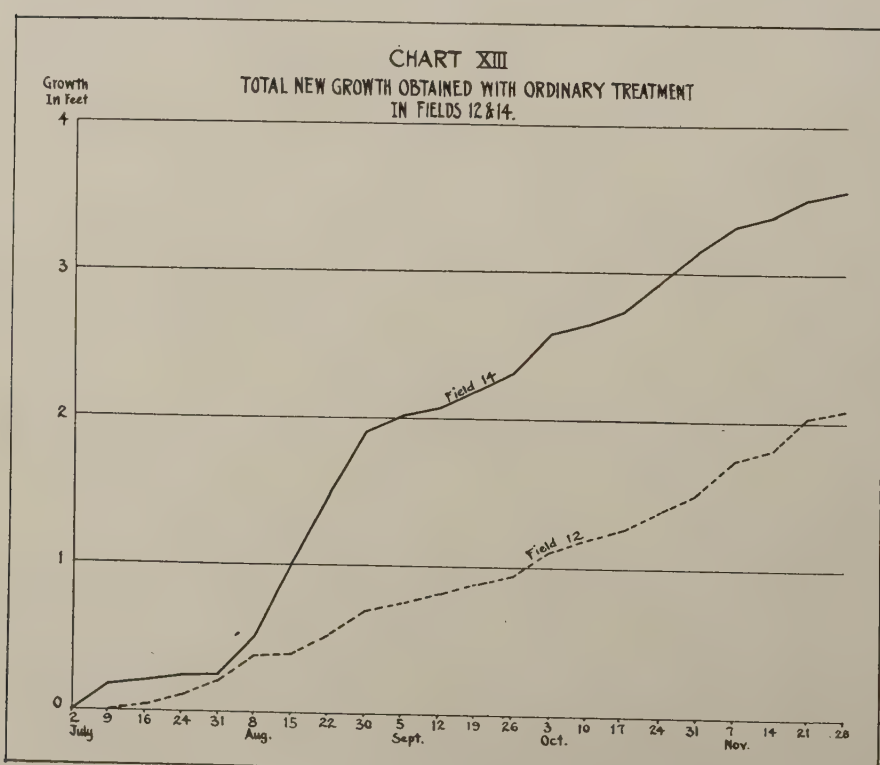


CHART XIII
TOTAL NEW GROWTH OBTAINED WITH ORDINARY TREATMENT IN FIELDS 12 & 14.
Growth In Feet
4
3
2
1
0
Field 14
Field 12
2 July
9
16
24
31
8 Aug.
15
22
30
5 Sept.
12
19
26
3 Oct.
10
17
24
31
7 Nov.
14
21
28

IRRIGATION REQUIRED, MINIMUM REQUIREMENT REGULAR ROUNDS.

Date	Cane to be Irrigated 6-12 Months Cane	Young Cane	Gallons per Day 6-12 Months Cane	Gallons per Day Young Cane	Total Gallons per Day
Jan. 1................	1,150	0	....	....	....
Feb. 1................	1,150	0	....	....	....
Mar. 1	1,150	300 ratoons	4,684,065	1,221,930	5,905,995
		250 plant		9,969,071	
April 1	1,150	300 ratoons	4,684,065	1,221,930	6,875,066
May 1	1,150	....	4,684,065	1,221,930	6,875,066
June 1...............	1,150	....	4,684,065	1,221,930	6,875,066
July 1	1,150	....	4,684,065	1,221,930	6,875,066
Aug. 1	1,150	....	4,684,065	1,221,930	6,875,066
Sept. 1...............	1,150	....	4,684,065	1,221,930	6,875,066
Oct. 1................	1,150	....	4,684,065	1,221,930	6,875,066
Nov. 1...............	1,150	....	4,684,065	1,221,930	6,875,066

If we allow 30% increase for transmission losses we find that approximately 9,000,000 gallons per day will be required under this minimum irrigation scheme. As the present irrigation supply may drop down close to 5,000,000 gallons per day in dry weather it is obvious that it will not be possible to follow this plan unless some additional water can be developed.

Summarized Recommendations for Further Work.

1. When the final water supply is known, adjust the irrigation schedule so as to make regular rounds of the fields under irrigation.

2. Keep all ditches and distributing laterals free from cane or other growth.

3. Make a complete study of transmission losses on the present system, so as to find what per cent of the supply is seeping out of the ditches. With this data in hand, it will be a simple matter to find whether it will pay to line all the main ditches and laterals with some type of concrete. It may be possible to bring the irrigation water up towards our figure for minimum irrigation by this method alone.

4. Investigate the possibility of overhead irrigation similar to the system now installed at Hawi. This system would be an alternative to lining the ditches. Overhead irrigation increases the duty of water and makes it possible to put in minimum irrigations without loss in transmission.

5. Continue the present experiments up to the time of harvesting, with such additional new areas as may prove advisable. In this further work it will be advisable to try and combine studies of growth by elongation with growth in cubic contents, so as to obtain more correct figures for semi-dry land cane.

Carbon Content of Plantation Soils

By W. T. McGeorge.

Introduction.

The organic matter of the soil has served as an incentive for extensive investigations on soil carbon and nitrogen. The latter has been studied by Kelley (6) on Hawaiian soils, but little attention appears to have been given to the carbon. In the past the humus determination, which to a ceraitn exent measures the more completely disintegrated or hydrolysed forms of organic matter, has been applied as an indication of the organic content of the soil. With the steady tendency towards absolute analyses, the total carbon determination has been more extensively applied of late. During the examination of Field 20, Oahu Sugar Co., where H 109 cane appeared to be suffering from root-rot, a notable absence of "life" in the soil was suggested. A comparative study has therefore been made of the carbon content of this soil as compared with other Island districts as well as those of the mainland.

The properties of soil organic matter are legion. It increases the water-holding capacity, improves the mechanical condition, imparting a crumb structure to clay and a greater cohesion to sand. It aids in maintaining a more uniform soil temperature, dark soils absorbing more heat. It increases the availability of plant food provided the proper environment is at hand and by serving as a source of energy, favors the growth of micro-organisms. Hopkins says, "It is the decay of organic matter and not the mere presence of it that gives life to the soil."

In studies on the carbon nutrition of plants, this element, like nitrogen, has been shown to pass through a rather definite cycle reaching its final simplified form, carbon dioxide, after passing through, in the presence of an oxidizing environment, complex bacterial decomposition products. This is well described by Russell as follows:

$$\text{Organic} + \text{oxygen} = \text{carbon dioxide} + \text{water}$$

On this basis he has noted a marked relation between fertility and oxidation in the soil, for in the absence of air or oxygen, a reducing reaction will result in other products being formed, some of which are toxic. Carbon dioxide is the principal available form of carbon, being present as such in the air and soil atmosphere and combined as soluble and insoluble inorganic carbonates. It should be mentioned, however, that there is some evidence of the assimilation of carbon in the form of sugars, alcohols, aldehydes and organic acids.

In general, investigations have shown that the carbon content of the soil is higher than the subsoil, higher in clays than sandy soils, in pastures than cultivated areas, and in humid than dry sections.

The principal sources of organic matter in soils, are crop residues, weeds, green crops and manures. It is a notable fact that a number of crops have enough vegetable matter, roots and stubble, to restore any loss. This is especially true when these crops receive little or no cultivation. Soils may lose carbon by leaching, evolution of carbon dioxide, and removal by crops, but any such losses are undoubtedly slight.

According to soil literature 2% is a good average organic content. Lyon and Fippen (7; p. 125) have compiled the following table from soil analyses of samples taken from all parts of the United States:

	Sandy soils % organic matter		Loam and clay soils % organic matter	
	Soil	Subsoil	Soil	Subsoil
Northeastern States	1.66	0.60	3.73	1.35
Southeastern States	0.93	0.41	1.53	0.73
North Central States	1.84	0.76	3.06	1.07
South Central States	1.16	0.55	1.80	0.65
Semi-arid States	0.99	0.62	2.64	1.11
Arid States	0.89	0.64	1.05	0.62

Bradley (3) reports .73 to 1.53% carbon in Oregon soils, and noted a heavy decrease in carbon when cropped to wheat. Blair and McClean (2) report 1 to 2% carbon in New Jersey soils and a decrease of .2% carbon on cultivated plots from 1909 to 1916. Swanson and Latshaw (9) found that the loss of carbon is confined to the top soil. In the semi-arid districts of Kansas they noted 30% less carbon in the cropped soils than the virgin. Alway (1) reports 1.7 to 3.07% carbon in Nebraska soils with a carbon nitrogen ratio of 11.2 to 13.6. Gortner (5) reports 1.63 to 10.08% carbon in Minnesota soils with some peats at 49% carbon. It is evident from these figures that there is not a great variation in average mainland soils.

Soil Samples.

Eighty samples of soil were used in this study representing a wide variety of types from 23 plantations located on Hawaii, Maui, Oahu and Kauai. Total carbon was determined in all samples, carbonate carbon in 63 and pentosans in 21. The pentosan content of dried cane leaves was also determined in order to compare with the pentosan content of the soil.

Methods.

Total carbon was determined by the wet combustion method using chromic and sulphuric acids and carbonate carbon with dilute hydrochloric acid, as described in "Methods of Analysis", Assoc. Official Agric. Chemists, 1919, page 309. Pentosans were determined by the furfural-phloroglucid method also described in the above Methods, page 96. The results are given in the following table, all being calculated to the water free basis. The moisture content of the air dry soil is also given in order to illustrate the relation of organic content to water-holding capacity:

TABLE I.

SHOWING RELATION OF CARBON CONTENT IN PLANTATION SOILS.

HAWAII

Soil No.	Plantation	Soil Description	Total Carbon	Carbonate Carbon	Pentosans	Moisture	Nitrogen	Carbon Nitrogen Ratio	Carbon Pentosan Ratio
798	Hilo Sugar Co.	Yellow Silty Loam	12.00	....	....	14.1	...	....	....
802	Hilo Sugar Co.	Yellow Silty Loam	11.40	....	....	14.1	...	....	....
806	Hilo Sugar Co.	Yellow Silty Loam	10.90	....	....	14.6	...	....	....
810	Hilo Sugar Co.	Yellow Silty Loam	11.45	....	....	13.8	...	....	....
765	Onomea Sugar Co.	Yellow Silty Loam	7.78	.016	.45	12.0	...	....	17.3
1097	Onomea Sugar Co.	Yellow Silty Loam	8.81	.007	....	14.8	...	....	....
1101	Onomea Sugar Co.	Yellow Silty Loam	10.10	.015	....	15.5	...	....	....
549	Hakalau Plantation Co.	Brown Yellow Silty Loam	10.90	....	.63	16.5	.64	17.0	17.3
770	Hakalau Plantation Co.	Yellow Silty Loam	8.27	....	....	13.8	...	....	....
1013	Kaiwiki Sugar Co.	Brown Silty Loam	7.17	.016	.49	18.4	.51	13.9	14.6
1017	Kaiwiki Sugar Co.	Brown Silty Loam	9.61	....	.51	20.2	.61	15.7	18.8
1030	Kaiwiki Sugar Co.	Brown Silty Loam	8.70	.046	.42	14.9	.61	14.2	20.7
1038	Kaiwiki Sugar Co.	Brown Silty Loam	12.95	....	....	23.6	.74	17.5	....
1040	Kaiwiki Sugar Co.	Dark Brown Sandy Loam	13.00	.027	1.00	25.8	.81	15.9	13.0
1070	Hamakua Mill Co.	Yellow Silty Loam	11.50	.011	.67	19.7	...	....	22.2
1074	Hamakua Mill Co.	Yellow Silty Loam	13.11	.009	....	20.8	...	....	....
1078	Hamakua Mill Co.	Yellow Silty Loam	8.94	.014	....	22.2	...	....	....
200	Honokaa Sugar Co.	Yellowish Brown Silty Loam	10.78	.032	....	16.9	.86	12.5	....
146	Honokaa Sugar Co.	Yellowish Brown Silty Loam	8.12	.022	....	13.0	.71	11.4	....
164	Honokaa Sugar Co.	Yellowish Brown Silty Loam	6.26	.021	....	13.2	.57	10.9	....
254	Pacific Sugar Mill Co.	Brown Silty Loam	6.78	.020	.40	13.6	.52	13.0	17.2
286	Pacific Sugar Mill Co.	Brown Silty Loam	12.69	.059	....	17.5	.79	16.1	....
1090	Niulii Mill & Plant Co.	Greyish Silty Loam	2.89	.001	.14	5.9	...	....	20.6
1093	Niulii Mill & Plant. Co.	Greyish Silty Loam	2.89	.005	....	5.8	...	....	....

SHOWING RELATION OF CARBON CONTENT IN PLANTATION SOILS

Soil No.	Plantation	Soil Description	Total Carbon	Carbonate Carbon	Pentosans	Moisture	Nitrogen	Carbon Nitrogen Ratio	Carbon Pentosan Ratio
		MAUI							
910	Pioneer Mill Co.	Red Clay Loam	1.89	.001	.17	9.3	.22	8.8	11.1
930	Pioneer Mill Co.	Red Clay Loam	.65	....	....	7.7	.10	6.7	....
933	Pioneer Mill Co.	Red Clay Loam	1.71	.015	....	7.3	.19	8.9	....
938	Pioneer Mill Co.	Reddish Brown Clay Loam	1.20	.000	....	5.2	.13	8.2	....
946	Pioneer Mill Co.	Reddish Brown Clay Loam	2.14	.001	....	7.5	.17	12.6	....
949	Pioneer Mill Co.	Reddish Brown Clay Loam	1.62	.014	....	7.3	.13	12.7	....
710	Maui Agricultural Co.	Red Clay Loam	1.19	.014	....	4.7	...	....	....
		OAHU							
834	Waimanalo Sugar Co.	Greyish Brown Clay Loam	3.13	.026	....	15.3	.21	14.7	....
848	Waimanalo Sugar Co.	Grey Brown Clay Loam	2.33	.018	.11	12.5	.20	11.5	21.1
866	Waimanalo Sugar Co.	Red Clay Loam	3.20	.011	.24	7.1	.30	10.6	13.3
* 867	Waimanalo Sugar Co.	Red Clay Loam	1.95	.019	.18	7.6	...	....	10.8
872	Waimanalo Sugar Co.	Grey Clay Loam	2.25	.238	....	9.2	.18	11.3	....
* 873	Waimanalo Sugar Co.	Grey Clay Loam	1.53	.033	....	10.1	...	....	....
722	Experiment Station, Waipio.	Brown Clay Loam	1.03	.004	.07	6.0	.10	9.2	13.1
438	Ewa Plantation Co.	Dark Grey Clay Loam	1.47	.040	....	8.6	.13	11.3	....
* 439	Ewa Plantation Co.	Dark Grey Clay Loam	.96	.075	....	9.0	...	....	....
412	Ewa Plantation Co.	Red Clay Loam	1.52	.008	....	4.6	.11	25.4	....
322	Ewa Plantation Co.	Reddish Grey Clay Loam	1.58	.013	....	3.2	.10	15.8	....
428	Ewa Plantation Co.	Reddish Brown Clay Loam	1.02	.001	.07	6.1	.08	12.7	14.5
* 429	Ewa Plantation Co.	Reddish Brown Clay Loam	.58	.001	.09	6.5	...	....	6.4
239	Honolulu Plantation Co.	Yellow Red Clay Loam	3.53	.900	....	7.5	...	....	....
3	Experiment Station, Makiki.	Dark Clay Loam	1.19	.098	....	7.0	...	....	....
1108	Oahu Sugar Co.	Red Clay Loam	1.52	.006	.089	5.5	.21	7.2	17.1
*1109	Oahu Sugar Co.	Red Clay Loam	.72	.006	.055	5.0	.10	7.2	13.1
1110	Oahu Sugar Co.	Red Clay Loam	1.61	....	....	4.7	.20	8.0	....
*1111	Oahu Sugar Co.	Red Clay Loam	.89	....	....	5.8	.13	6.8	....
1112	Oahu Sugar Co.	Red Clay Loam	1.41	....	....	6.4	.16	8.8	....
*1113	Oahu Sugar Co.	Red Clay Loam	.99	....	....	7.1	.11	9.0	....

* Subsoils.

TABLE I (Cont.)

SHOWING RELATION OF CARBON CONTENT IN PLANTATION SOILS

Soil No.	Plantation	Soil Description	Total Carbon	Carbonate Carbon	Pentosans	Moisture	Nitrogen	Carbon Nitrogen Ratio	Carbon Pentosan Ratio
1114	Oahu Sugar Co.	Red Clay Loam	1.86	.014	.119	6.8	.22	8.5	15.6
*1115	Oahu Sugar Co.	Red Clay Loam	.96	.006	....	7.5	.11	8.7	....
1116	Oahu Sugar Co.	Red Clay Loam	1.61	....	....	6.2	.18	9.0	....
*1117	Oahu Sugar Co.	Red Clay Loam	.90	....	....	6.9	.11	8.7	....
1118	Oahu Sugar Co.	Red Clay Loam	1.54	....	....	9.0	.16	9.6	....
*1119	Oahu Sugar Co.	Red Clay Loam	.79	....	....	7.1	.10	7.9	....
1120	Oahu Sugar Co.	Red Clay Loam	2.09	.032	.098	5.1	.22	9.5	21.3
*1121	Oahu Sugar Co.	Red Clay Loam	1.22	.024	....	4.5	...	....	....
		KAUAI							
1003	Kekaha Sugar Co.	Reddish Brown Clay Loam	1.54	.085	....	10.6	...	....	....
405	McBryde Sugar Co.	Red Clay Loam	3.01	.032	....	4.8	...	....	....
984	Koloa Sugar Co.	Brown Clay Loam	4.03	.015	....	10.6	.33	12.5	....
986	Koloa Sugar Co.	Brown Clay Loam	4.46	.004	....	10.2	.40	11.2	....
973	Koloa Sugar Co.	Brown Clay Loam	4.22	.008	....	9.4	.42	10.0	....
974	Koloa Sugar Co.	Dark Brown Clay Loam	5.66	3.110	....	8.3	.22	25.8	....
954	Koloa Sugar Co.	Red Clay Loam	4.09	.001	....	10.2	.28	14.8	....
955	Koloa Sugar Co.	Yellow Clay Loam	4.46	.011	....	11.2	.27	16.7	....
957	Koloa Sugar Co.	Grey Clay Loam	5.94	.001	....	12.9	.42	14.2	....
998	Lihue Plantation Co.	Red Clay Loam	3.14	.057	....	6.0	...	....	....
367	Grove Farm Plantation	Yellow Clay Loam	4.14	.001	....	9.6	...	....	....
990	Grove Farm Plantation	Yellow Clay Loam	4.80	.028	....	9.5	...	....	....
1001	Grove Farm Plantation	Yellow Clay Loam	5.11	.000	....	9.2	...	....	....
1002	Grove Farm Plantation	Yellow Clay Loam	4.28	.008	....	8.2	...	....	....
995	Kilauea Sugar Plant. Co.	Yellow Clay Loam	3.38	.011	....	5.5	...	....	....
996	Kilauea Sugar Plant. Co.	Yellow Clay Loam	3.04	.052	....	6.0	...	....	....
382	Kilauea Sugar Plant. Co.	Brown Yellow Clay Loam	5.08	.165	....	5.5	.30	16.9	....
* 383	Kilauea Sugar Plant. Co.	Yellow Clay Loam	3.01	.034	....	7.3	...	....	....
Cane Leaves			....	....	30.1	....	...	....	....

* Subsoils.

Considering the total carbon determinations by districts and islands it is at once apparent that the high carbon content is associated with humidity. The highest figures were obtained on the soils from the Hamakua coast district. The lowest results were from the more or less arid districts on Maui and Oahu. There is a distinct relation between the color and carbon content, all the red soils being among the lowest and practically all the high carbon soils being of the yellow or yellowish brown type. It is of further interest to note the association of high moisture holding capacity with high carbon and vice versa. On the whole, variation in carbon content extends over a wide range, 1.02 to 13.11 per cent, the subsoils being invariably lower than the respective surface soil.

In other than the soils from the coral areas, there is only a very small amount of carbonate carbon. This applies to practically all soil types regardless of location. For this reason, for all practical purposes, total carbon in Hawaiian soils may be considered all organic. Rarely does the carbonate carbon exceed .025 per cent in the noncoral areas.

The pentosans are a group of exceedingly complex carbohydrates of unsatisfactory classification. They have been assigned the generic formula $C_5H_8O_4$, and are usually present in cellular and woody tissue. A sample of dried cane leaves from Waipio on analysis was shown to contain 30.1% pentosans on the water free basis. The purpose of the pentosan determination in the soil was to note any presence of residual cane leaves in the soil. It will be noted in the table that the high carbon soils from the Hamakua district are highest in pentosan carbon, which we may term undecayed organic matter. In a manner, this might indicate slower decay in such soils, but when we figure on the basis of ratio of pentosans to total carbon there is no greater variation than is noted in the soils from the other districts. Hence, while there is considerable variation in the pentosan content of island soils, there is no distinctive relation except that both the pentosan content and carbon-pentosan ratio are markedly lower in the subsoil.

The carbon-nitrogen ratio usually falls within the range of 10 to 12 in mainland soils. In the Hawaii and Kauai soils both nitrogen and carbon are high as is also the nitrogen-carbon ratio, while in the Maui and Oahu soils, especially the red clay type, the ratio is low. According to Brown and Allison (4) a ratio of 1:12 or above indicates satisfactory bacterial activities while ratios below 1:10 indicate sluggish bacterial action. If this applies to our soils, our humid soils possess the more satisfactory environment for bacterial action. They noted a higher degree of fertility in those soils of high ratio. This at least does not hold true for island soils. Read (8) on comparing the carbon nitrogen ratio of soils from widely scattered states on the mainland was unable to correlate soil productivity with this ratio.

On the whole, as compared to mainland soils, analyses indicate Hawaiian soils to be well supplied with organic matter. But, in a manner, this is misleading in that there is a radical difference in the chemical composition and physical nature. The nature of local soils is such that the organic matter is a very important factor in controlling the water-holding capacity. The rainy districts on Hawaii, which are very high in organic matter, have an extremely high water-holding capacity. On the other hand, most of the red soils in the drier districts would undoubtedly be greatly improved in water-holding range by a higher organic content.

Relation of Carbon Content to Cropping.

During the course of the above investigation the question arose as to the exhaustion of organic matter in the sugar lands by the present cropping system

and especially the practice of trash burning at harvest. Some time ago Mr. Stewart collected a set of soil samples at Ewa Plantation in order to study salt or alkali accumulation. These samples included border or uncultivated and field samples from nine different fields. Total carbon determinations were made in these soils and the results compared. A description of the soil samples follows:

Field 25, a dark brown clay adobe. Sample 440 from the field and 826 from the border of the road alongside Field 25.

Field 27, a greyish black clay. Sample 438 from the field and 824 from the border of the road alongside.

Field 19F, a brown silty clay loam. Sample from the field, 422 and sample 788 from alongside the plantation road running from the government road to the plantation stables.

Field 13B, greyish black clay adobe. Samples 322, 324, 326, 328, 330 from the field and 781 from the lower border and 782 on mauka edge between the cane and railroad track.

Apokaa Field, brown clay loam. Field sample 442 and border sample 830.

Field A, reddish brown silty clay loam. Field samples 424, 426, 428, 430. Border samples 794, 796, 832 at different points alongside the field.

Field 17A, dark red clay loam. Field samples 408, 410, 412, 414, and border samples 790, 792.

Field 2A, reddish brown silty clay loam. Field sample 436. Border samples 784 and 786 from the churchyard, planted to Bermuda grass, at the edge of the field.

Field 7, dark brown clay loam. Field samples 304, 306, 308, 310, 312, 314, 316, 318. Border samples 773, 775, 777, 779 taken at different points along the edge of the field.

The carbon content of these soils is given in the following table:

	Soil No.	Field	Soil No.	Border	No. Years Cropped
Field 25	440	1.24	826	1.55	25
Field 27	438	1.50	824	1.96	22
Field 19F	422	1.31	788	0.74	29
Field Apokaa	442	1.29	830	0.79	23
Field A	424	1.05	794	0.98	..
	426	1.41	796	1.08	..
	428	1.02	832	1.06	..
	430	1.14	...	....	..
Average		1.15		1.04	29
Field 17A..................	408	1.11	790	0.91	..
	410	1.10	792	1.45	..
	412	1.59	...	....	..
	414	0.97	...	....	..
Average		1.19		1.18	30
Field 2A..................	436	1.65	784	1.49	..
	...	....	786	1.52	..
Average		1.65		1.51	31
Field 7....................	304	0.85	773	1.13	..
	306	1.16	775	1.34	..
	308	1.41	777	1.96	..
	310	1.24	779	1.53	..
	312	1.28	...	....	..
	314	1.44	...	....	..
	318	1.59	...	....	..
Average		1.28		1.49	31
Field 13..................	322	1.15	781	2.68	..
	324	1.41	782	1.10	..
	326	1.59	...	....	..
	328	1.07	...	....	..
	330	1.93	...	....	..
Average		1.43		1.89	30

These results are of interest in that only 4 fields are lower in carbon than the uncropped border while 5 are higher. Field samples vary from 0.85 to 1.93 per cent while the border samples vary from 0.74 to 2.68. The average of all field samples is 1.30 per cent while that of the border samples is 1.37. Average figures then indicate a very slight loss, but if we allow for the range of variation in both cropped and uncropped soils, we might safely interpret the above data as showing no loss in organic matter. This is of especial interest in view of the fact that no other plantation soils are subjected to more intensive culture than the Ewa soils; that the heaviest tonnages in the islands are harvested from their fields and further that trash burning at harvest is the universal practice.

In view of the above it is of interest to note some unpublished data obtained by Mr. Agee some years ago showing the dry matter produced by a Yellow Caledonia plant crop 14½ months old producing 46.4 tons cane per acre.

	Dry Matter Tons per Acre	% of Total
Cane tops	3.46	14.60
Cane	10.72	45.23
Dead leaves	4.88	20.59
Young shoots	.15	.63
Root stock, etc.	2.76	11.65
Roots	1.73	7.30
Total	23.70	100.00
All underground parts	4.49	18.95

In other words, dry weight of underground parts amounts to nearly 5 tons per acre per crop. Hence, supposing all leaves and trash are destroyed by burning, which is not entirely true, the organic material added to the soil by a cane crop is far in excess of the average weight of a green manure cover crop. Green cover crop plowed under will add 300 to 1,000 lbs. organic matter per acre (dry basis). The following table taken from Lyon & Fippen (7, p. 386) shows the relative *green* weight of the more important cover crops:

Red clover	6 tons per acre
Crimson clover	6 " " "
Alsike clover	5 " " "
Alfalfa	8 " " "
Cow peas	6 " " "
Soy beans	6 " " "
Field peas	5 " " "

It is also of interest to know that at Rothamsted a field continuously in wheat since 1843, plot 2b has received 14 tons farmyard manure annually and the first 9 inches of soil have gained only .098 per cent carbon in 12 years, and in 50 years 1.342 per cent more than continuously cropped unmanured plot. On the basis of 5 tons underground parts and figuring 3,000,000 lbs. soil per acre foot, a 45-ton cane crop adds approximately 0.3 per cent organic matter to the top foot of soil per crop.

Conclusions.

Analysis of Hawaiian soils as compared with mainland soils indicates an ample supply of organic matter.

The highest organic content is found in soils from the humid districts while the red soils of the dry sections are lowest. The moisture holding range of the latter would be greatly increased by a higher organic content.

On the basis of data obtained from the analysis of a set of soil samples from 9 fields at Ewa Plantation there is no indication that the present cropping system is depleting the organic matter of plantation soils.

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Summary of Results in Cutting Back Experiments

By J. A. Verret.

To date eight cut back experiments have been harvested. Two more are being conducted, one at Koloa and one at Pioneer.

The results obtained were as follows:

Location	Date Planted or Ratooned	Date Cut Back	Variety	Treatment	Yield per Acre Cane	Yield per Acre Sugar	Loss from Cutting Back Cane	Loss from Cutting Back Sugar	% Tassel
Waipio Substation	Ratoon—April	July 8	Lahaina	Cut back	48.7	5.74	— 3.9	—0.20	3.5%
			Lahaina	Not cut back	52.6	5.94	......	......	.....
Experiment D	Ratoon—April	July 8	Yellow Caledonia	Cut back	72.6	7.89	— 3.3	—0.23	None
			Yellow Caledonia	Not cut back	75.9	8.12	......	......	.....
	Ratoon—April	July 8	D 1135	Cut back	80.5	7.77	—12.9	— 2.00	0.35%
			D 1135	Not cut back	93.4	9.77	......	......	.....
O. S. Co. Field 49, Exp. 12	Ratoon—May 1-8	July 7	D 1135	Cut back	89.6	12.28	— 7.5	—1.16	None
				Not cut back	97.1	13.44	......	......	.....
O. S. Co. Field 15 Obs. Test 1	Plant—May 1-15	June 29	H 109	Cut back	86.9	9.07	—18.3	—2.07	None
				Not cut back	104.2	11.14	......	......	.....
Ewa Plant. Co. Apokaa 2 field	Ratoon—May 10	July 7	H 109	Cut back	97.4	12.14	—14.0	—1.99	.....
				Not cut back	111.4	14.13	......	......	.....
Ewa Plant. Co. Field 1-C	Ratoon—March 25	July 6	H 109	Cut back	88.7	10.07	— 7.65	—0.77	.....
				Not cut back	96.4	10.87	......	......	.....
Ewa Plant Co. Field 1-A	Ratoon—May 4	July 5	H 109	Cut back	83.7	10.46	+ .70*	+0.31*	.....
				Not cut back	83.0	10.15	......	......	.....
Ewa Plant Co. Field 10-A	Ratoon—May 23	July 6	H 109	Cut back	122.3	14.23	— 6.14	—1.13	.....
				Not cut back	128.4	15.36	......	......	.....
Ewa Plant. Co. Field 19-B	Ratoon—May 4	July 8	Lahaina and H 109	Cut back	88.0	11.09	— 6.88	—1.12	.....
				Not cut back	94.9	12.21	......	......	.....

* Gain.

The details of these experiments will be found as follows:

Waipio D—Planters' Record, Vol. XIX, No. 1.
O. S. Co. 12—Planters' Record, Vol. XXIV, No. 3.
O. S. Co. Obs. 1—Planters' Record, Vol. XXIV, No. 6.

Details of the Ewa Experiments will be found elsewhere in this issue. The work at Ewa is summarized as follows by the plantation:

A gain of 1.08 tons of sugar per acre was secured by not cutting back, being the result of the additional 7.45 tons of cane per acre. These figures are the averaged yields of the five tests. These tests covered five typically different locations on the plantation with varying conditions of drainage, slope and character of soil.

The saving of labor was an extra advantage. This was effected in two ways:

(1) No labor used in the operation of cutting back.

(2) Less labor used in hoeing as the result of the quicker closing in of the non-cut-back cane, thus shading out the weeds.

The cane yields are briefly tabulated:

Field	Character of Field	Tons of Cane per Acre Non-cut-back	Cut-back
AS No. 2	Deep soil, steep slope	111.37	97.39
No. 1-C	Shallow soil, steep slope	96.38	88.73
No. 1-A	Deep soil, fair slope	82.96	83.66
No. 10-A	Deep soil, level	128.42	122.28
No. 19-B	Deep soil, level	94.91	88.03
	Average	101.53	94.08

Gain for Non-cut-back................7.45 tons cane per acre.

The experiments vary in the gain of the check plots over the plots cut back. In Field Apokaa 2, there was an average gain of practically 13 tons cane per acre; in Field 1-C a gain of 7.65 tons cane per acre; in 10-A a gain of 6.14 tons cane, and 19-B a gain of 6.88 tons cane, while in Field 1-A, the yields for all practical purposes were the same.

Four experiments gave the following average increase in tons sugar per acre:

Field AS No. 2	1.99	tons sugar per acre
Field 10-A	1.13	" " " "
Field 10-B	1.12	" " " "
Field 1-C	.77	" " " "
Average of four tests	1.43	" " " "

The fifth experiment in Field No. 1-A gave no gain, and discounting the extra poor juices in Plot 8-X, there would be no loss either.

In three cases the plots where no cutting back was practiced averaged better juices, in one case average juice was about the same, and in one case poorer for the non-cut-back plots.

In the work so far done we find that seven out of eight experiments show a loss for cutting back. In the eighth experiment the differences were small. In all cases cutting back was done in early July when the cane was from two to three and a half months old.

In these tests the cane was not forced before cutting back, that is, but very little irrigation was done, and no fertilization, until after cutting back. If the cane was forced from the beginning it is reasonable to assume that greater differences would be shown in favor of not cutting back.

In connection with cutting back it would be of value to keep records of the tasseling on different parts of the plantations. A good way to keep these records would be to use different colors on a map of the plantation; different colors indicating different degrees of tasseling.

With this to help, cutting back, when necessary, could be done much more intelligently. Parts of the plantation which show a tendency to tassel freely could be cut back while the other parts would be left alone.

We have noted time and again that tassels were plentiful in one part of a field while near by there were none.

This field census on tassels would locate these areas and be very convenient at "cut back" time.

Seedling Work in the Kohala District for 1923*

By W. C. Jennings.

Mr. Kutsunai spent a few days in Kohala at the beginning of the tasseling season and consequently the work received the benefit of his experience from the start. Whatever changes that were necessary, in the plan of work based on his instructions, were brought about by the uncertain weather of Kohala, which is rather unfavorable for seedling work.

Nursery Construction.

The cold frames are long, unfloored benches, four feet wide, with a wall eighteen inches high on the north or back side, and are partitioned off into nine-foot sections, each section having a muslin covered frame cover which slopes to the south with pitch enough to carry off heavy rain.

The benches are made four feet wide, though too wide to work conveniently, for the reason that, with the high back wall necessary to break the wind, a narrower bench would be too dark. If old lumber is used in the construction of the cold frames, the interiors are whitewashed. The partitions are placed to break currents of air that might sweep up and down the length of the benches otherwise.

Better drainage is assured by not flooring the benches, but supporting the fuzz or germination flats with 1x3 slats laid across the benches and spaced according to the size of the flats in use.

* In this report on the 1923 seedling propagation work in Kohala, to be brief, only methods which differ from Makiki practices will be touched on.

The benches are laid out so as to extend slightly to the northwest and southeast across the nursery. With this arrangement it is believed we get the best protection from the prevailing easterly wind, while at the same time the cold frames are allowed the maximum benefit of the sun, (1) by being able to open the frames directly to the morning sun, and (2) when frames are closed the sun is allowed to strike the muslin covers at an angle favorable to filtration of indirect sunlight.

Selection of Tassels.

As in the work on Oahu, tassels were selected in localities favorable for the desired crosses, always cutting tassels from varieties on the leeward side of the supposedly pollinating variety.

Tassels were cut as soon as the top half or less had ripened, as the heaviest germinations were secured from the tops. Before the lower part of a tassel has ripened, as a rule, the top part which sets the most seed has either been blown to pieces by the wind or damaged by rain. Whenever tassels at the right stage for cutting are found, it has been the experience here, that it is best to collect as great a quantity as possible at that time, testing a few for germination, and using or discarding the balance according to the results of this test. Owing to the uncertain weather conditions here, it is almost impossible to cut a few tassels for a germination test with the idea, if the test be successful, of going back later to cut enough for your needs, as it was proven many times here last year that tassels cut at one time may give good germination, while those cut in the same field at the same apparent stage of maturity, a week later, may not.

Tassels cannot be dried in muslin bags here as is done at Makiki. Due no doubt to the green condition of the tassels when cut and the more humid climate, it has been found necessary to hang the tassels up in small bundles for a few days, or until the fuzz begins to drop, before placing in bags. This is not a very convenient method as only one lot of tassels can be kept in a room at one time as the flying florets would soon become mixed. During rainy weather it is sometimes difficult to keep tassels from spoiling even when not in bags.

Planting and Care of Germination Flats.

As a result of several unsuccessful attempts with the soil mixtures used at Makiki and failure with any soils containing much humus or organic matter, it is the conclusion here, that in Kohala and Hamakua where there is apt to be a large percentage of cloudy and rainy days with low temperature during December and January, when most of the planting must be done, that soil as free as possible of organic matter, yet still retaining some degree of fertility, must be used in germination flats.

In every case where fuzz was planted in flats containing any amount of stable manure or compost, and a few days of cloudy and rainy weather occurred, the fuzz became a slimy mass of fungi and algae, even though in some cases no water was applied during the whole period.

Soil that is considered the best available here was taken from around the foundations of an old stable, where no fresh organic material, with the exception

of decaying weeds growing on the spot, has been added for probably twenty years. Though very fertile, this soil is too heavy to be considered ideal for seedling work, having very little trace of humus and being almost clay loam in texture. In this soil most of the 1923 seedlings were propagated.

Addition of enough coral sand to improve the texture of this soil, although apparently not injuring germination, appeared to lessen the fertility of the mixture to such an extent that the seedlings made too slow a growth and were caught by dampening off, or smothered by blue green algae.

No Kohala cut tassels gave very heavy germination, the heaviest being from H 109, which gave about 100 germinations per flat. With Oahu tassels as high as 1,800 to 2,000 germinations per flat were secured. To get the estimated 25,000 Striped Tip germinations, it was necessary to cut many thousands of tassels and plant hundreds of flats. The Striped Tip fuzz gave on an average about twenty to thirty germinations per flat.

Care After First Transplanting.

Seedlings were transplanted from germination flats when about one inch high. They were shaded for three or four days after this operation and several days were spent breaking them in gradually to the sun. If at any time two or three days of cloudy weather occurred the seedlings were shaded the first clear day and once again broken in to full time exposure to direct sunlight, and this breaking in process was repeated after every period of cloudy weather until the plants were seven or eight inches high.

With the exception of a possible more sparing use of water and more care about exposure to direct sunlight, planting operations, care of fuzz flats, and care of flats after first transplanting, were much the same as outlined in Mr. Kutsunai's report.

Care of Potted Seedlings.

When the seedlings are from three to five inches high the largest and most vigorous appearing plants are transferred to pots. In a week or two the same flats are gone over again and these seedlings that have not started a more vigorous growth and deemed not large enough for transferring to pots are destroyed.

The transplanting to pots is done under cover and the plants are shaded until they appear to have recovered from the effects of this operation, after which several days more elapse before they are left uncovered all day.

When the potted seedlings are accustomed to being all day in the sun, have recovered from the effects of transplanting, and appear to be making good growth again, some of the protection against the wind is removed. This checks the growth considerably in all the plants, but those which do not grow at all or seem to be dying are destroyed and the pots used again. It is estimated that between 16,000 and 18,000 seedlings were eliminated in this way, between the time of first transplanting and setting out in the field. Only a limited number of seedlings can be handled in the fields and it seemed a reasonable supposition that the majority of the seedlings discarded in this manner would be weaker and less vigorous plants.

No fertilizer of any kind was applied until a very short time (generally a week or ten days) before setting the seedlings out in the field, as it was thought inadvisable to promote a lush, rank growth which would receive a severe check when the plants were put out in the field.

General Observations.

Tassels appeared continuously in different parts of the Kohala district from the first of November until the latter part of January. During this season no general order, either varietal or locational, for the appearance of tassels was observed.

Striped Tip tassels cut at a distance from other tasseling varieties in every case failed to germinate, while all the Striped Tip germinations secured were from tassels which had developed a few feet to the leeward side of another tasseling variety. These results lead us to believe that we have our desired Striped Tip X H 109 and Striped Tip X D 1135 crosses among the seedlings now in the field.

Striped Tip seedlings, of the same age, were very uniform as to size, when compared with seedlings of other parentage, and very few were discarded. To date this uniformity is still noticeable in the field.

In setting out seedling station No. 1 at Niulii Mill & Plantation, very rigid selection was practiced, which resulted in a lot of seedlings very uniform as to size. At this time, although many of the seedlings have stalks which have formed four or five joints, this station has almost as uniform appearance as the surrounding crop cane.

A list of seedlings set out this year, with female and probable male parent, follows:

From Kohala tassels:

Striped Tip X D 1135	12,200
Striped Tip X H 109	800
H 109 X Striped Tip	1,100
H 109 X ?	1,000
D 1135 X Striped Tip	90
Badila X ?	220

From Oahu tassels:

H 1801	2.600
H 5978	2,000
H 109	3,680
D 1135	110
Lahaina	100

The number of seedlings set out on each plantation follows:

Niulii Mill & Plantation	2,000
Halawa Plantation, Ltd	2,000
Kohala Sugar Co	6,700
Union Mill Co	4,100
Hawi Mill & Plantation Co., Ltd	8,200

Handy Irrigation Factors

By J. S. B. Pratt, Jr.

The use of the small meter of the submerged orifice or rectangular weir type brings the terms "acre foot", "acre inch", "second foot", and others into more common usage in the Islands. At the last annual meeting of the Association of Hawaiian Sugar Techonologists, the writer presented several charts showing what a "man's water" represented. These, with various irrigation factors, and conversion tables are given here as a handy reference for irrigation use. The following references will give more complete tables:

Handbook of Hydraulics—King.
Measurement of Irrigation Water. U. S. Reclamation Service, 1923.
Construction and Use of Farm Weirs. Farmers' Bull. 813.
Measurement of Irrigation Water. Great Western Meter Co.
Measurement of Water. Idaho Bull. 127.
Practical Information on the Measurement of Irrigation Water. Utah Circ. No. 36.
Harper's Hydraulic Tables.
Use of Water in Irrigation. Fortier.

1 U. S. gallon = 231 cubic inches
= 0.13368056 cu. ft.
= 8.3388 lbs.

1 Million gallons = 231,000,000 cu. in.
= 133,680.555 cu. ft.

1 Million gallons per day (24 hours) = 1.54723 cu. ft. per sec.
= 3.0688833 acre feet per 24 hours.
= 1.2787 acre feet per 10 hours.
= 36.82660 acre inches per 24 hours.
= 15.344 acre inches per 10 hours.
= 694.44 gallons per minute.
= 41,666.66 gallons per hour.
= 416,666.66 gallons per 10 hours.

1 Acre inch = the volume of water that will cover an acre 1 inch deep.
= 6,272,640 cu. in.
= 3,630 cu. ft.
= 27,154.2857 gallons.
= .027,154,285,7 mil. gallons.

1 Acre inch per 10 hours = .108⅓ sec. ft.
1 Acre inch per 24 hours = .042139 sec. ft.

1 Acre foot = volume of water that will cover an acre 1 foot deep.
= 75,271,680 cu. in.
= 43,560 cu. ft.
= 325,851.4286 gals.
= .325,851 + mil. gals.

1 Acre foot per hour = 12.1 sec. ft.
1 Acre foot per 10 hours = 1.21 sec. ft.
1 Acre foot per 24 hours = .5041 2/3 sec. ft.
1 Cu. ft. = 7.48051948 gals.

1 Cu. ft. water weighs approximately 62½ lbs.
1 Cu. ft. per sec. = about 1 acre inch per hour.
(1 sec. ft.) = about 2 acre ft. in 24 hours.
= 1728 cu. in. per sec.
= 7.48051948 gals. per sec.
= .00002295684 acre ft. per sec.
= 448.83117 gals. per min.
= .0013774105 acre ft. per min.
= 26,929.8702 gals. per hour.
= .082644628 acre ft. per hour.
= 646,316.88 gals. per day (24 hours).
= 1.9834711 acre ft. per day (24 hours).
1 Sec. ft. per 10 hours = 9.917355 acre in.
= .826446 acre ft.
1 Sec. ft. per 24 hours = 23.80164 acre in.
= 1.98347 acre ft.

Man's Water.

There is no established unit to represent the amount of water handled by one man. The term varies on the different plantations and as to whether a man is irrigating in small cane or big cane.

To give an idea of the amount of water passing over a 90° weir or a rectangular weir in terms of man's water, we have chosen two units (a and b) and present the following tables and graphs:

WITH 90° WEIR.

(a) Where 100,000 gallons per 10 hours = 1 man's water = .371 cu. ft. per sec.

	Cu. Ft. per Sec.	Head in Inches
1 Man's water	.371	5½″
2 Men's "	.742	7⅜″
3 " "	1.113	8⅝″
4 " "	1.484	9¾″
5 " "	1.855	10⅝″

(b) Where 80,000 gallons per 10 hours = 1 man's water = .3 cu. ft. per sec.

	Cu. Ft. per Sec.	Head in Inches
1 Man's water	.3	5⅛″
2 Men's "	.6	6 13/16″
3 " "	.9	8 13/16″
4 " "	1.2	8⅞″
5 " "	1.5	9¾″

WITH RECTANGULAR WEIR.

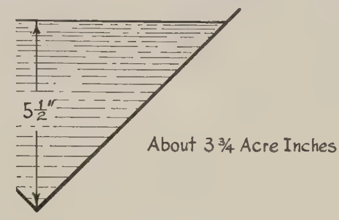
(a) Where 100,000 gallons per 10 hour = 1 man's water = .371 cu. ft. per sec.

	Head in Inches		
Men's Water	2′ Weir	3′ Weir	4′ Weir
10 Men's water	.70	.53	.43
20 " "	...	.85	.69
30 " "	...	1.10	.92
40 " "	...	1.33	1.12
50 " "	...	....	1.30

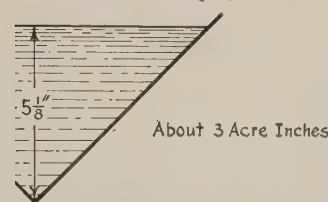
90° V-NOTCH WEIR

ONE MAN'S WATER

WHERE 100,000 GALS. PER 10 HOURS = 1 MAN'S WATER (~~3.71~~ .371 CU. FT. PER SEC.)

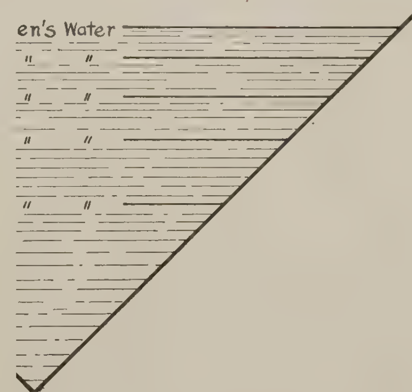


= 1 MAN'S WATER (.3 CU. FT. PER SEC.)

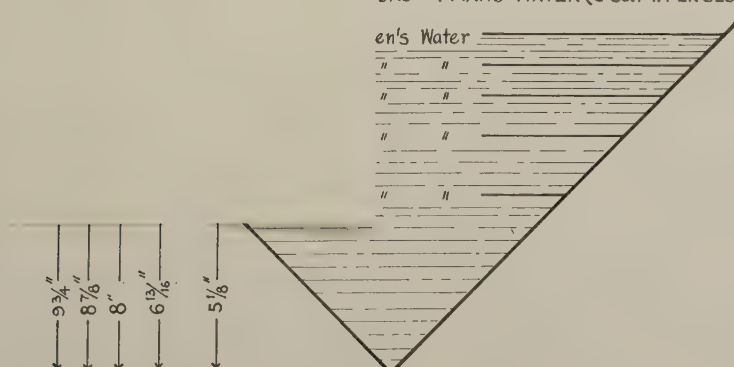


E MEN'S WATER

S = 1 MAN'S WATER (.3,71 CU. FT. PER SEC.)



URS = 1 MAN'S WATER (.3 CU. FT. PER SEC.)



ERRATA

THE HAWAIIAN PLANTERS' RECORD

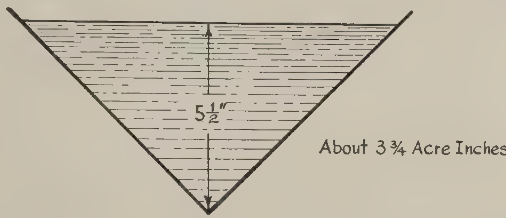
Vol. XXVIII, No. 2

Page 273. A misplaced decimal point occurs in each of the four parenthetical notes. In two cases 3.71 *should read* .371, and in two cases 3 *should read* .3. The diagram will then conform with the text on page 272.

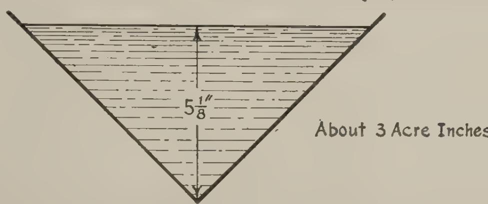
90° V-NOTCH WEIR

ONE MAN'S WATER

WHERE 100,000 GALS. PER 10 HOURS = 1 MAN'S WATER (~~3.71~~ .371 CU. FT. PER SEC.)

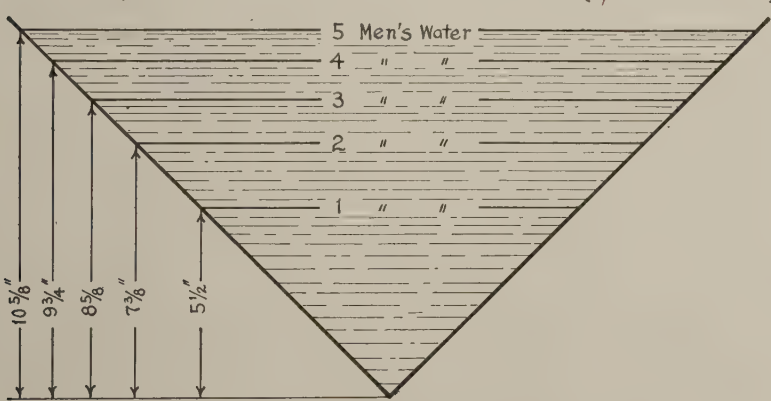


WHERE 80,000 GALS. PER 10 HOURS = 1 MAN'S WATER (·3 CU. FT. PER SEC.)

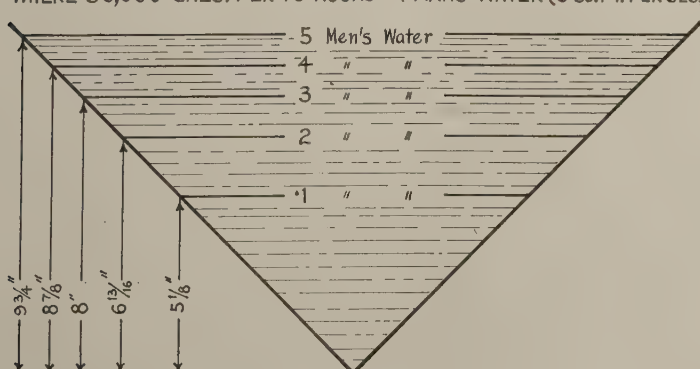


ONE TO FIVE MEN'S WATER

WHERE 100,000 GALS. PER 10 HOURS = 1 MAN'S WATER (.371 CU. FT. PER SEC.)



WHERE 80,000 GALS. PER 10 HOURS = 1 MAN'S WATER (·3 CU. FT. PER SEC.)



(b) Where 80,000 gallons per 10 hours = 1 man's water = .3 cu. ft. per sec.

Men's Water	Head in Inches 2′ Weir	Head in Inches 3′ Weir
10 Men's water	.62	.46
20 " "	.97	.74
30 " "	...	.98
40 " "	...	1.15
50 " "	...	1.35

CONVERSION TABLE.

Million Gallons To

Million Gals. per 24 Hrs.	U. S. Gals. per Min.	Cu. Ft.* per Sec. for 24 Hrs.	Acre Feet** per 10 Hrs.	Acre Feet** per 24 Hrs.	Acre Inches*** per 10 Hrs.	Acre Inches*** per 24 Hrs.
1	694.44	1.5472	1.2787	3.06888	15.344	36.8266
2	1,388.88	3.0944	2.5574	6.13777	30.688	73.6532
3	2,083.33	4.6416	3.8361	9.20664	46.032	110.4798
4	2,777.77	6.1888	5.1148	12.2755	61.376	147.3064
5	3,472.22	7.7360	6.3935	15.3444	76.720	184.1330
6	4,166.66	9.2832	7.6722	18.4133	92.064	220.9596
7	4,861.11	10.8304	8.9509	21.4822	107.408	257.7862
8	5,555.55	12.3776	10.2296	24.5310	122.752	294.6128
9	6,249.99	13.9248	11.5083	27.6199	138.096	331.4394
10	6,944.44	15.4720	12.7870	30.6888	153.440	368.2660

*1 sec. ft. = .646,316.88 mil. gals. **1 acre ft. = .325,851 mil. gals. ***1 acre in. = .027,154 mil. gal.

CONVERSION TABLE.

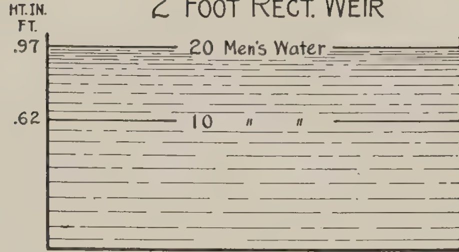
Million Gallons to Acre Feet—1 Million Gallons = 3.0688833 Acre Feet.

Mil. Gal.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
0	0.00	0.3069	0.6138	0.9207	1.2276	1.5344	1.8413	2.1482	2.4551	2.7620
1	3.0689	3.3758	3.6827	3.9895	4.2964	4.6033	4.9102	5.2171	5.5240	5.8309
2	6.1378	6.4447	6.7515	7.0584	7.3653	7.6722	7.9791	8.2860	8.5929	8.8998
3	9.2066	9.5135	9.8204	10.1273	10.4342	10.7411	11.0480	11.3549	11.6618	11.9686
4	12.2755	12.5824	12.8893	13.1962	13.5031	13.8100	14.1169	14.4238	14.7306	15.0375
5	15.3444	15.6513	15.9582	16.2651	16.5720	16.8789	17.1857	17.4926	17.7995	18.1064
6	18.4133	18.7202	19.0271	19.3396	19.6409	19.9477	20.2546	20.5615	20.8684	21.1753
7	21.4822	21.7891	22.0960	22.4028	22.7097	23.0166	23.3235	23.6304	23.9373	24.2442
8	24.5511	24.8580	25.1648	25.4717	25.7786	26.0855	26.3924	26.6993	27.0062	27.3131
9	27.6199	27.9268	28.2337	28.5406	28.8475	29.1544	29.4613	29.7682	30.0751	30.3819
10	30.6888	30.9957	31.3026	31.6094	31.9164	32.2233	32.5302	32.8371	33.1439	33.4508

Mil. Gal.	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
Acre Ft.	.000	.03069	.06138	.09207	.12276	.15344	.18413	.21482	.24551	.27620

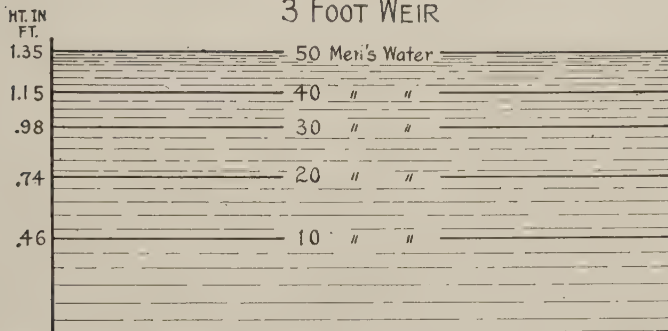
To convert mil. gals. to acre inches multiply by 12.

2 Foot Rect. Weir

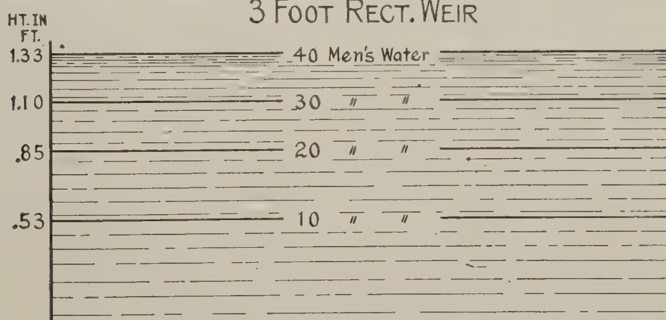


Where 80,000 Gals. Per 10 Hours = 1 Man's Water.

3 Foot Weir

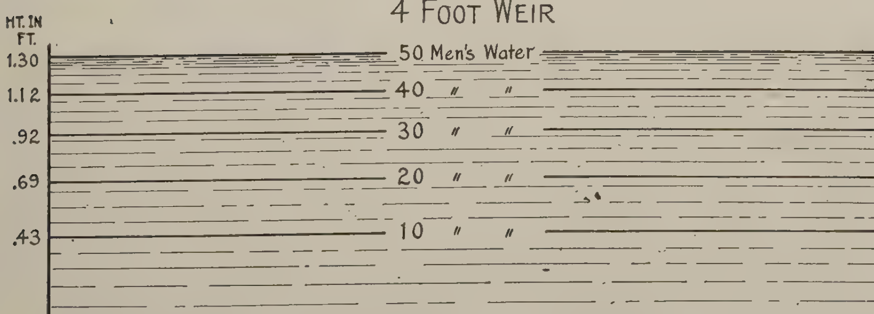


3 Foot Rect. Weir



Where 100,000 Gals. Per 10 Hours = 1 Man's Water.

4 Foot Weir



CONVERSION TABLE.*

Acre Feet to Million Gallons—1 Acre Foot = .325,851 Million Gallons.

Acre Ft.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
0	.00	.0326	.0652	.0978	.1303	.1629	.1955	.2281	.2607	.2933
1	.3259	.3584	.3910	.4236	.4562	.4888	.5214	.5539	.5865	.6191
2	.6517	.6843	.7169	.7495	.7820	.8146	.8472	.8798	.9124	.9450
3	.9776	1.0101	1.0427	1.0753	1.1079	1.1405	1.1731	1.2056	1.2382	1.2708
4	1.3034	1.3360	1.3686	1.4012	1.4337	1.4663	1.4989	1.5315	1.5641	1.5967
5	1.6293	1.6618	1.6944	1.7270	1.7596	1.7922	1.8248	1.8574	1.8899	1.9225
6	1.9551	1.9877	2.0203	2.0529	2.0854	2.1180	2.1506	2.1832	2.2159	2.2484
7	2.2810	2.3135	2.3461	2.3787	2.4113	2.4439	2.4765	2.5091	2.5416	2.5742
8	2.6068	2.6394	2.6720	2.7047	2.7371	2.7697	2.8023	2.8349	2.8675	2.9001
9	2.9327	2.9652	2.9978	3.0304	3.0630	3.0956	3.1282	3.1608	3.1933	3.2259
10	3.2581	3.2911	3.3237	3.3563	3.3889	3.4214	3.4540	3.4866	3.5192	3.5518

Acre Ft.	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
Mil. Gal.	.000	.00326	.00652	.00978	.01303	.01629	.01955	.02281	.02607	.02933

CONVERSION TABLE.

Second Feet to Acre Feet.

Sec. Ft.	Acre Feet per 10 Hours	Acre Feet per 24 Hours
.01	.00826	.01983
.02	.01653	.03967
.03	.02479	.05950
.04	.03306	.07934
.05	.04132	.09917
.06	.04959	.11901
.07	.05785	.13884
.08	.06612	.15868
.09	.07438	.17851
.10	.08265	.19835
.20	.16529	.39669
.30	.24794	.59504
.40	.33058	.79339
.50	.41322	.99173
.60	.49587	1.19008
.70	.57852	1.38843
.80	.66116	1.58678
.90	.74381	1.78512
1.00	.82645	1.98347

1 sec. ft. per 10 hrs. = .82645 acre ft.
1 sec. ft. per 24 hrs. = 1.98347 acre ft.

* To convert acre inches to million gallons divide by 12 (1 acre inch) = .027,154 million gallons).

CONVERSION TABLE.

Acre Feet to Second Feet.

Acre Ft.	Sec. Ft. per 10 Hours	Sec. Ft. per 24 Hours
.01	.01210	.00504
.02	.02420	.01008
.03	.03630	.01513
.04	.04840	.02017
.05	.06050	.02521
.06	.07260	.03025
.07	.08470	.03529
.08	.09680	.04033
.09	.10890	.04537
.10	.12100	.05042
.2	.2420	.10083
.3	.3630	.15125
.4	.4840	.20167
.5	.6050	.25208
.6	.7260	.30250
.7	.8470	.35292
.8	.9680	.40333
.9	1.0890	.453758
1.00	1.2100	.5041⅔

1 acre ft. per 1 hr. = 12.1 sec. ft.
1 acre ft. per 10 hrs. = 1.21 sec. ft.
1 acre ft. per 24 hrs. = .5041⅔ sec. ft.

CONVERSION TABLE.

Second Feet to Acre Inches.

Sec. Ft.	Acre Inches per 10 Hours	Acre Inches per 24 Hours
.01	.09917	.23802
.02	.19835	.47603
.03	.29752	.71405
.04	.39669	9.5207
.05	.49587	1.19008
.06	.59504	1.42810
.07	.69421	1.66612
.08	.79339	1.90413
.09	.89256	2.14215
.10	.99174	2.38017
.20	1.98347	4.76033
.30	2.97521	7.14050
.40	3.96694	9.52066
.50	4.95868	11.90083
.60	5.95041	14.28100
.70	6.94215	16.66116
.80	7.93388	19.04132
.90	8.92562	21.42149
1.00	9.917355	23.80165

1 sec. ft. per 10 hrs. = 9.917355 acre inches.
1 sec. ft. per 24 hrs. = 23.80165 acre inches.

CONVERSION TABLE.

Acre Inches to Second Feet.

Acre Inches	Second Feet per 10 Hours	Second Feet per 24 Hours
.01	.00108	.00042
.02	.00217	.00084
.03	.00325	.00126
.04	.00433	.00168
.05	.00542	.00210
.06	.00650	.00252
.07	.00758	.00294
.08	.00867	.00336
.09	.00975	.00378
.10	.01083	.00420
.2	.02167	.00840
.3	.03250	.01260
.4	.04333	.01681
.5	.05417	.02101
.6	.06500	.02521
.7	.07583	.02941
.8	.08666	.03361
.9	.09750	.03781
1.00	.108⅓	.0420139

1 acre in. per 10 hrs. = .108⅓ sec. ft.
1 acre in. per 24 hrs. = .0420139 sec. ft.

CONVERSION TABLE.

Second Feet per 24 Hours to Million Gallons per Day (24 Hours).
1 Second Foot = 646,316.88 Gallons per Day (24 Hours).

Sec. Ft.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
0	.00	.0646	.1293	.1939	.2585	.3232	.3878	.4524	.5171	.6819
1	0.6463	.7109	.7756	.8402	.9048	.9695	1.0341	1.0987	1.1634	1.2280
2	1.2926	1.3573	1.4219	1.4865	1.5512	1.6158	1.6804	1.7451	1.8097	1.8743
3	1.9390	2.0036	2.0682	2.1328	2.1975	2.2621	2.3267	2.3914	2.4560	2.5206
4	2.5853	2.6499	2.7145	2.7792	2.8438	2.9084	2.9731	3.0377	3.1023	3.1670
5	3.2316	3.2962	3.3608	3.4255	3.4901	3.5547	3.6194	3.6840	3.7486	3.8133
6	3.8779	3.9425	4.0072	4.0718	4.1364	4.2011	4.2657	4.3303	4.3950	4.4596
7	4.5242	4.5888	4.6535	4.7181	4.7827	4.8474	4.9120	4.9766	5.0413	5.1059
8	5.1705	5.2352	5.2998	5.3644	5.4291	5.4937	5.5583	5.6230	5.6876	5.7522
9	5.8169	5.8815	5.9461	6.0107	6.0754	6.1400	6.2046	6.2693	6.3339	6.3985
10	6.4632	6.5278	6.5924	6.6571	6.7217	6.7863	6.8510	6.9156	6.9802	7.0449

Sec. Ft.	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
Mil. Gal.	.000	.0065	.0129	.0194	.0259	.0323	.0388	.0452	.0517	.0582

DISCHARGE TABLE FOR 90° TRIANGULAR NOTCH WEIR.

From the Formula Q = 2.49 H .248.

Head in Feet	Head in Inches	Discharge in Second Feet (Q)	Head in Feet	Head in Inches	Discharge in Second Feet (Q)
.20	2 3/8	.046	.70	8 3/8	1.03
.21	2 1/2	.052	.71	8 1/2	1.06
.22	2 5/8	.058	.72	8 5/8	1.10
.23	2 3/4	.065	.73	8 3/4	1.14
.24	2 7/8	.072	.74	8 7/8	1.18
.25	3	.080	.75	9	1.22
.26	3 1/8	.088	.76	9 1/8	1.26
.27	3 1/4	.096	.77	9 1/4	1.30
.28	3 3/8	.106	.78	9 3/8	1.34
.29	3 1/2	.115	.79	9 1/2	1.39
.30	3 5/8	.125	.80	9 5/8	1.43
.31	3 3/4	.136	.81	9 3/4	1.48
.32	3 13/16	.147	.82	9 13/16	1.52
.33	3 15/16	.159	.83	9 15/16	1.57
.34	4 1/16	.171	.84	10 1/16	1.61
.35	4 3/16	.184	.85	10 3/16	1.66
.36	4 5/16	.197	.86	10 5/16	1.71
.37	4 7/16	.211	.87	10 7/16	1.76
.38	4 9/16	.226	.88	10 9/16	1.81
.39	4 11/16	.240	.89	10 11/16	1.86
.40	4 13/16	.256	.90	10 13/16	1.92
.41	4 15/16	.272	.91	10 15/16	1.97
.42	5 1/16	.289	.92	11 1/16	2.02
.43	5 3/16	.306	.93	11 3/16	2.08
.44	5 1/4	.324	.94	11 1/4	2.13
.45	5 3/8	.343	.95	11 3/8	2.19
.46	5 1/2	.362	.96	11 1/2	2.25
.47	5 5/8	.382	.97	11 5/8	2.31
.48	5 3/4	.403	.98	11 3/4	2.37
.49	5 7/8	.424	.99	11 7/8	2.43
.50	6	.445	1.00	12	2.49
.51	6 1/8	.468	1.01	12 1/8	2.55
.52	6 1/4	.491	1.02	12 1/4	2.61
.53	6 3/8	.515	1.03	12 3/8	2.68
.54	6 1/2	.539	1.04	12 1/2	2.74
.55	6 5/8	.564	1.05	12 5/8	2.81
.56	6 3/4	.590	1.06	12 3/4	2.87
.57	6 13/16	.617	1.07	12 13/16	2.94
.58	6 15/16	.644	1.08	12 15/16	3.01
.59	7 1/16	.672	1.09	13 1/16	3.08
.60	7 3/16	.700	1.10	13 3/16	3.15
.61	7 5/16	.730	1.15	13 13/16	3.52
.62	7 7/16	.760	1.20	14 3/8	3.91
.63	7 9/16	.790	1.25	15	4.33
.64	7 11/16	.822			
.65	7 13/16	.854			
.66	7 15/16	.887			
.67	8 1/16	.921			
.68	8 3/16	.955			
.69	8 1/4	.991			

DISCHARGE OF RECTANGULAR CONTRACTED WEIRS IN SECOND FEET.

Length of Weir in Feet.

Compiled from "Measurement of Water," U. S. Reclamation Service, 1923.

H. D.	1.	1.5	2.	3.	4.	5.	6.	7.	8.	9.
.10	.103	.156	.208	.314	.419	.524	.630	.735	.840	.945
.12	.135	.204	.273	.412	.550	.689	.827	.965	1.10	1.24
.14	.169	.257	.344	.518	.693	.867	1.04	1.22	1.39	1.56
.16	.206	.313	.419	.632	.845	1.06	1.27	1.48	1.70	1.91
.18	.245	.372	.499	.754	1.01	1.26	1.52	1.77	2.02	2.28
.20	.286	.435	.584	.881	1.18	1.48	1.78	2.07	2.37	2.67
.22	.328	.500	.672	1.02	1.36	1.70	2.05	2.39	2.73	3.08
.24	.373	.568	.764	1.16	1.55	1.94	2.33	2.72	3.11	3.50
.26	.419	.639	.860	1.30	1.74	2.18	2.63	3.07	3.51	3.95
.28	.466	.712	.959	1.45	1.95	2.44	2.93	3.43	3.92	4.41
.30	.514	.788	1.06	1.61	2.16	2.70	3.25	3.80	4.34	4.89
.32	.564	.866	1.17	1.77	2.37	2.98	3.58	4.18	4.78	5.39
.34	.615	.945	1.28	1.94	2.60	3.26	3.92	4.58	5.24	5.90
.36	.686	1.03	1.39	2.11	2.82	3.54	4.26	4.98	5.70	6.42
.38	.743	1.11	1.50	2.28	3.06	3.84	4.62	5.40	6.18	6.96
.40	.801	1.20	1.62	2.46	3.30	4.14	4.99	5.83	6.67	7.51
.42	.860	1.28	1.74	2.64	3.55	4.46	5.36	6.27	7.18	8.08
.44	.920	1.37	1.86	2.83	3.80	4.77	5.75	6.72	7.69	8.66
.46	.981	1.46	1.98	3.02	4.06	5.10	6.14	7.18	8.22	9.26
.48	1.04	1.56	2.11	3.22	4.32	5.43	6.54	7.64	8.75	9.86
.50	1.11	1.65	2.24	3.41	4.59	5.77	6.95	8.12	9.30	10.48
.52	.....	1.74	2.37	3.62	4.86	6.11	7.36	8.61	9.86	11.1
.54	.....	1.84	2.50	3.82	5.14	6.46	7.79	9.11	10.4	11.8
.56	.....	1.94	2.64	4.03	5.43	6.82	8.22	9.61	11.0	12.4
.58	.....	2.04	2.77	4.24	5.71	7.18	8.66	10.1	11.6	13.1
.60	.....	2.14	2.91	4.46	6.00	7.55	9.10	10.6	12.2	13.7
.62	.....	2.24	3.05	4.68	6.30	7.93	9.55	11.2	12.8	14.4
.64	.....	2.34	3.19	4.90	6.60	8.31	10.0	11.7	13.4	15.1
.66	.....	2.44	3.34	5.12	6.91	8.69	10.5	12.3	14.0	15.8
.68	.....	2.55	3.58	5.35	7.22	9.08	11.0	12.8	14.7	16.6
.70	.....	2.65	3.74	5.58	7.53	9.48	11.4	13.4	15.3	17.3
.72	.....	2.76	3.90	5.81	7.84	9.88	11.9	13.9	16.0	18.0
.74	.....	2.87	4.06	6.05	8.16	10.3	12.4	14.5	16.6	18.8
.76	.....	....	4.22	6.28	8.49	10.7	12.9	15.1	17.3	19.5
.78	.....	....	4.38	6.52	8.82	11.1	13.4	15.7	18.0	20.3
.80	.....	....	4.54	6.77	9.15	11.5	13.9	16.3	18.7	21.1
.82	.....	....	4.70	7.01	9.48	12.0	14.4	16.9	19.4	21.8
.84	.....	....	4.87	7.26	9.82	12.4	15.0	17.5	20.1	22.6
.86	.....	....	5.05	7.51	10.2	12.8	15.5	18.1	20.8	23.4
.88	.....	....	5.23	7.76	10.5	13.3	16.0	18.8	21.5	24.3
.90	.....	....	5.41	8.02	10.9	13.7	16.5	19.4	22.2	25.1
.92	.....	....	5.59	8.28	11.2	14.2	17.1	20.0	23.0	25.9
.94	.....	....	5.77	8.53	11.6	14.6	17.6	20.7	23.7	26.7
.96	.....	....	5.95	8.80	11.9	15.1	18.2	21.3	24.5	27.6
.98	.....	....	6.13	9.06	12.3	15.5	18.8	22.0	25.2	28.4
1.00	.....	....	6.31	9.32	12.7	16.0	19.3	22.6	26.0	29.3

Cutting Back Experiments at Ewa Plantation

By W. P. Alexander

The practice of the "cutting back" of H 109 young ratoon cane in July on the lands of the Ewa Plantation Company not only brings no benefit to the growing crop, but there may be also a definite loss in tonnage of cane and sugar when this procedure is followed. Such is the conclusion reached, after harvesting five well laid out and carefully conducted experiments for the 1923 crop. There was practically no tasseling of the cane in any of the experiments.

A gain of 1.08 tons of sugar per acre was secured by not cutting back, being the result of the additional 7.45 tons of cane per acre. The above figures are the averaged yields of the five tests. These tests covered five typically different locations on the plantation with varying conditions of drainage, slope and character of soil.

The saving of labor was an extra advantage. This was effected in two ways:

(1) No labor used in the operation of cutting back.

(2) Less labor used in hoeing as the result of the quicker closing in of the non-cut-back cane, thus shading out the weeds.

The cane yields are briefly tabulated below:

Field	Character of Field	Tons of Cane per Acre Non-cut-back	Cut-back
AS 2	Deep soil, steep slope	111.37	97.39
1-C	Shallow soil, steep slope	96.38	88.73
1-A	Deep soil, level	82.96	83.66
10-A	Deep soil, level	128.42	122.28
19-B	Deep soil, level	94.91	88.03
	Average	101.53	94.08

Gain for non-cut-back, 7.45 tons cane per acre.

The experiments vary in the gain of the check plots over the plots cut back. In Field Apokaa 2, there was an average gain of practically 13 tons cane per acre; in Field 1-C a gain of 7.65 tons cane per acre; in 10-A a gain of 6.14 tons cane and 19-B a gain of 6.88 tons cane, while in Field 1-A, the yields for all practical purposes were the same.

Four experiments gave the following average increase in tons sugar per acre:

Field AS 2	1.99 tons sugar per acre
" 10-A	1.13 " " " "
" 19-B	1.12 " " " "
" 1-C	.77 " " " "
Average of four tests	1.43 " " " "

The fifth experiment in Field 1-A gave no gain, and discounting the extra poor juices in Plot 8-X, there would be no loss either.

In three cases, the plots where no cutting back was practiced, averaged better juices; in one case average juice was about the same, and in one case poorer for the non-cut-back plots.

The above summarizes the data secured in a general way. A more detailed analysis of the cane and sugar yields of the harvesting figures from the five experiments follows:

APOKAA 2 (H 109) SUMMARY AVERAGE YIELDS.

	Area	No. of Plots	Cane	Quality Ratio	Sugar
Non-cut-back	.702	6	111.37	7.88	14.13
Cut-back	.658	6	97.38	8.02	12.14
Loss for cutting back			13.99	.14	1.99

This test was located on a steep slope on a pòrtion of the field that dried out very quickly. It is here that tasseling, if any, would be heaviest. The previous crop was harvested May 10 to 25, and the ratoons were not irrigated until after cutting back on July 7, 1921. Six hundred and forty-five lbs. per acre of nitrate of soda, equivalent to 100 lbs. of nitrogen, were applied to all plots on September 8-10, 1921. The experiment was irrigated about every 18 days. There was practically no tasseling during the winter and the greater growth in the non-cut-back plots showed up when the cane was six months old. The field was badly infested with nut grass. On March 15, 1922, ammonium nitrate was applied in the irrigation water at the rate of 500 lbs. per acre.

Plot yields charted in Fig. 1 are very consistently in favor of the non-cut-back plots. The exception, plot 10-C, is at the point where there is constant seepage from a pump discharge.

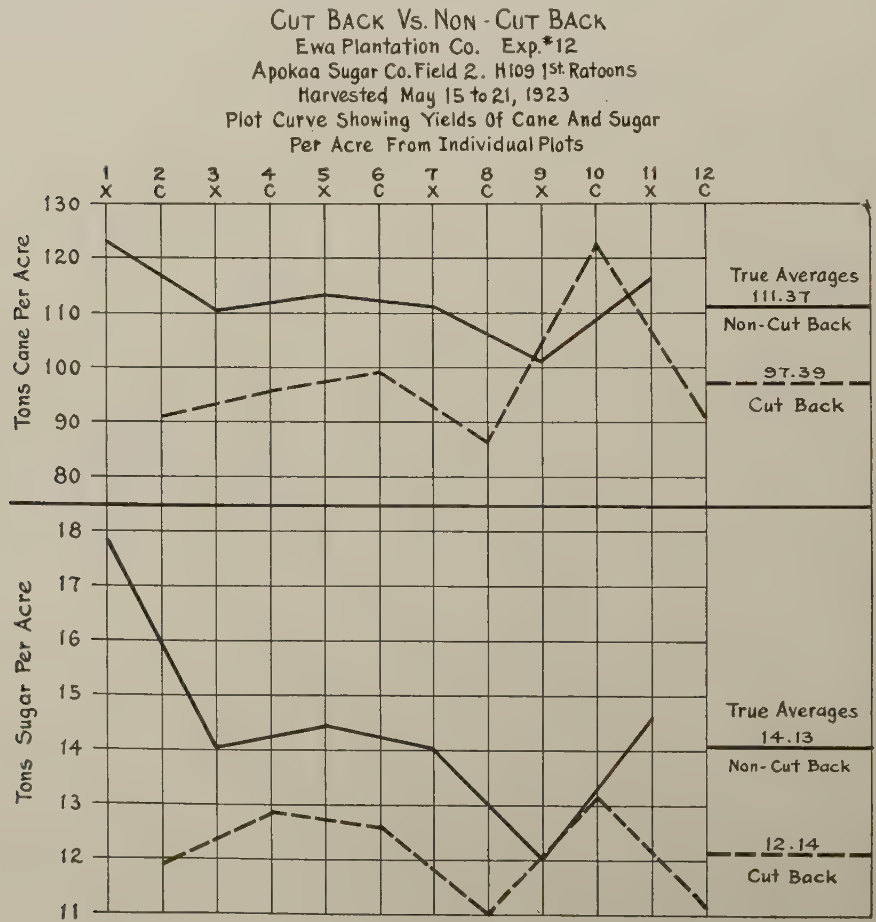


Fig. 1.

TABLE 1.

EWA PLANTATION CO.

Field AS 2 Cut-Back vs. Non-Cut-Back Experiment.

Harvested May 16-21, 1923.

Summary of Results.

Non-Cut-Back

Plot	Treatment	Area	Tons Cane Total	Tons Cane per Acre	Tons Sugar Total	Tons Sugar per Acre	Quality Ratio	Pol. % Cane	Brix	Pol.	Purity
1	Non-Cut-Back	0.047	5.7895	123.18	0.83906	17.85	6.90	15.42	20.40	18.80	92.16
3	"	0.143	15.7840	110.38	2.0133	14.08	7.84	13.86	18.90	16.90	89.42
5	"	0.138	15.6910	113.70	1.9938	14.45	7.87	13.94	19.30	17.00	88.08
7	"	0.125	13.9200	111.36	1.7553	14.04	7.93	13.86	19.20	16.90	88.02
9	"	0.116	11.7540	101.33	1.3960	12.03	8.42	13.20	18.60	16.10	86.56
11	"	0.089	10.3410	116.19	1.30075	14.615	7.95	13.78	19.00	16.80	88.42
	True Averages	0.658	73.2795	111.37	9.2994	14.13	7.88	13.88	19.13	16.93	88.50

Cut-Back

Plot	Treatment	Area	Tons Cane Total	Tons Cane per Acre	Tons Sugar Total	Tons Sugar per Acre	Quality Ratio	Pol. % Cane	Brix	Pol.	Purity
2	Cut-Back	0.142	12.9215	91.00	1.6957	11.94	7.62	14.19	19.20	17.30	90.10
4	"	0.126	12.1005	96.04	1.6242	12.89	7.45	14.43	19.40	17.60	90.72
6	"	0.122	12.1090	99.25	1.5386	12.61	7.87	13.94	19.30	17.00	88.08
8	"	0.138	11.9620	86.68	1.5180	11.00	7.88	14.02	19.60	17.10	87.24
10	"	0.106	13.0425	123.04	1.3949	13.16	9.35	12.05	17.30	14.70	84.97
12	"	0.068	6.2330	91.66	0.7564	11.12	8.24	13.61	19.40	16.60	85.57
	True Averages	0.702	68.3685	97.39	8.52475	12.14	8.02	13.69	18.98	16.70	87.99

FIELD 1-C (H 109) SUMMARY AVERAGE YIELDS.

	Area	No. of Plots	Cane	Quality Ratio	Sugar
Cut-back	1.089	4	88.73	8.81	10.07
Non-cut-back		4	96.38	8.89	10.84
Loss for cutting back			7.65	.08	.77

On a well drained pali slope the site for this experiment was chosen because it is here that tasseling is usually heaviest. The previous crop was harvested on March 25, 1921, and until the cane was cut back on July 6, 1921, the irrigation was not regular. It consisted of two or three rounds; just enough to keep the cane from dying out. Thereafter, irrigation was steady at between 15- and 20-day intervals. Even so, the leaves would often be curled before applying water. Fertilizer was applied on August 18, 1921, at the rate of 645 lbs. of nitrate of soda per acre. An excessive amount of weed growth appeared in the plots which had been cut back. Actual timing showed 77.5 per cent more labor required to hoe these plots over the non-cut-back plots. Tassels were almost a minus quantity. Plot 2 had 9; plot 4 had 3; and plot 6 had 2; otherwise there were none at all. The stalks in the non-cut-back plots appeared larger and longer than those in the cut-back plots. There were more stalks, however, in the latter plots.

Table 2 gives the detailed harvesting data for each plot. With the exception of plot 5, which is in more of a hollow, every check plot gave a higher yield than the cut-back plot adjoining. The average cane yields showed a gain of 9.68 tons of cane per acre where no cutting back was practiced. Plot 1 (cut-back) was exposed and poorly situated as regards fertility. It should be discarded. The average cane yield per acre then becomes 88.73 tons as against 86.70 tons, and the gain is reduced to 7.65 tons of cane per acre.

The quality of the juice varied from plot to plot, but averaging all plots was practically identical for cut-back and non-cut-back plots.

TABLE 2.

Field 1-C Cut-Back Experiment.

Harvesting Results—January 24, 1923

Summary of Results.

Plot	Treatment	Area	Total Tons Cane	Tons Cane per Acre	Tons Sugar per Acre	Quality Ratio	Brix	Pol'n	Purity
1	Cut-Back ..	0.151	11.97	79.27	9.61	8.25	18.6	16.3	87.6
3	" ..	0.096	10.0225	104.40	11.26	9.27	18.2	15.1	83.0
5	" ..	0.143	13.73	96.01	10.87	8.83	18.1	15.5	85.6
7	" ..	0.153	12.6625	82.76	9.83	8.42	18.6	16.1	86.6
9	" ..	0.157	12.30	78.34	8.81	8.89	18.0	15.4	85.6
True Averages...		0.700	60.6850	86.70	9.98	8.69	18.30	15.7	85.79
Omitting Plot 1		0.549	48.715	88.73	10.07	8.81	18.23	15.55	85.30
2	Non-Cut-Back	0.122	12.385	101.52	11.78	8.62	18.4	15.8	85.9
4	"	0.121	12.945	106.98	12.17	8.79	18.0	15.5	86.1
6	"	0.151	13.5825	89.95	10.47	8.59	18.8	16.0	85.1
8	"	0.146	13.135	89.97	9.34	9.63	17.1	14.4	84.2
True Averages...		0.540	52.0475	96.38	10.84	8.89	18.08	15.42	85.29

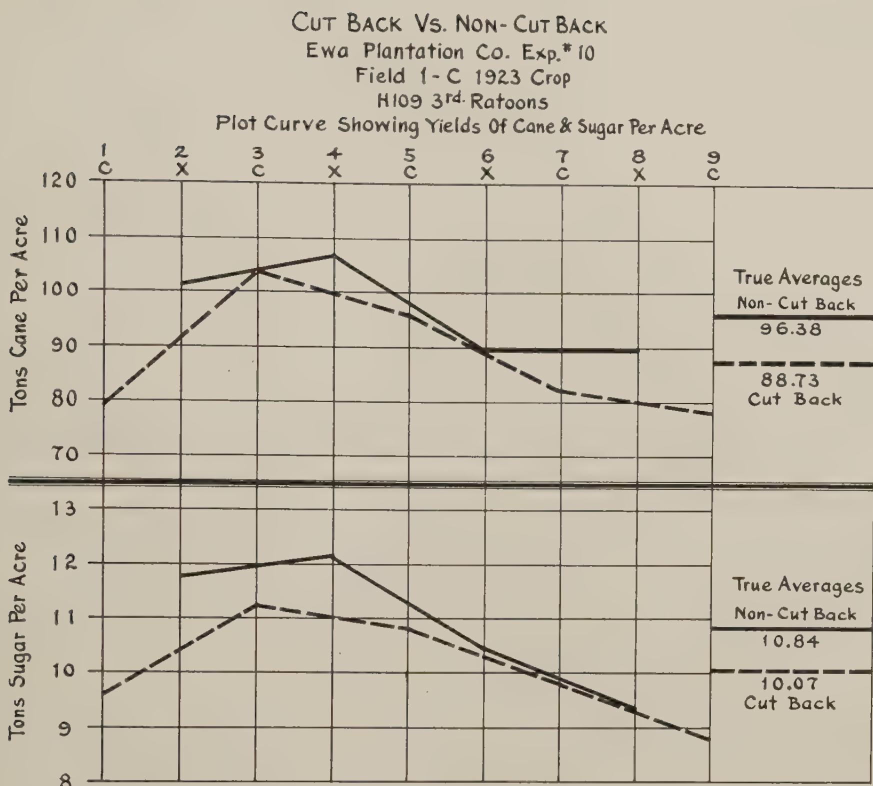


Fig. 2.

FIELD 1-A (H 109) SUMMARY AVERAGE YIELDS.

	Area	No. of Plots	Cane	Quality Ratio	Sugar
Cut-back	1.352	4	83.66	8.00	10.46
Non-cut-back	1.406	4	82.96	8.17	10.15
Gain for cut-back plots...............			.70	.17	.31

The average yields of cane per acre are very close. The sucrose content being lower in the non-cut-back plots, due principally to the poorer quality of Plot 8-X, the yields of sugar when averaged slightly favor the cut-back plots.

When the crop started the non-cut-back plots led those which had been cut back in height of cane. The inference would be, therefore, that cutting back induced more stooling which compensated for the loss in length of stalk.

The previous crop was harvested May 4, 1921, and the new ratoons were cut back on July 5, 1922. Weed growth was nil in the non-cut-back plots, although not very great in the adjacent cut-back plots. On August 23, the experiment received uniformly to all plots 645 lbs. of nitrate of soda per acre.

Field was irrigated at about 30-day intervals. On October 3, 1921, there was a heavy rain. The only tasseling in the experiment was along the ditch in the non-cut-back plots. On March 30, 1922, the entire experiment received 500 lbs. of ammonium nitrate in the irrigation water.

Field 1-A has fair slope with a well drained deep soil.

TABLE 3.

EWA PLANTATION COMPANY.

Field 1-A Cut-Back Experiment.

Date Harvested, January 27 to 29, 1923.

Summary of Results.

Plot	Treatment	Area	Total Tons Cane	Tons per Acre	Total Tons Sugar	Tons Sugar per Acre	Quality Ratio	Brix	Pol.	Purity	Grams P_2O_5 in 100 cc Juice
1	Cut-back	0.216	17.7075	81.98	2.267	10.50	7.81	19.10	17.00	89.00	0.048
3	"	0.379	29.5525	77.97	3.736	9.86	7.91	19.70	17.10	86.80	0.046
5	"	0.432	37.0000	85.65	4.7375	10.97	7.81	19.10	17.00	89.00	0.038
7	"	0.325	28.8525	88.78	3.394	10.44	8.50	18.30	15.90	86.89	0.029
True Averages		1.352	113.1125	83.66	14.139	10.46	8.00	19.05	16.75	87.93	0.036
2	Non-cut-back	0.290	21.9275	75.61	2.874	9.91	7.63	19.80	17.5	88.38	0.036
4	"	0.399	30.6125	76.72	3.996	10.02	7.66	19.90	17.5	87.94	0.038
6	"	0.404	34.240	84.75	3.981	9.85	8.60	18.30	15.8	86.34	0.029
8	"	0.313	29.855	95.38	3.4316	10.96	8.70	17.90	15.55	86.87	0.024
True Averages		1.406	116.635	82.96	14.276	10.15	8.17	18.90	16.50	87.30	0.031

FIELD 10-A (H 109) SUMMARY COUNTS AND AVERAGE YIELDS PER FOOT.

	Area	No. of Plots	Shoots Age 7 & 6 Mo.	Stalks at Harvest	Avge. Circumference*	Average Yields Cane	Q. R.	Sugar
Non-cut-back	.28	3	4.49	2.6082	.3632	128.42	8.36	15.36
Cut-back	.35	4	5.83	2.7325	.3494	122.28	8.59	14.23
Loss for cutting back						6.14	.23	1.13

* Average 800 stalks.

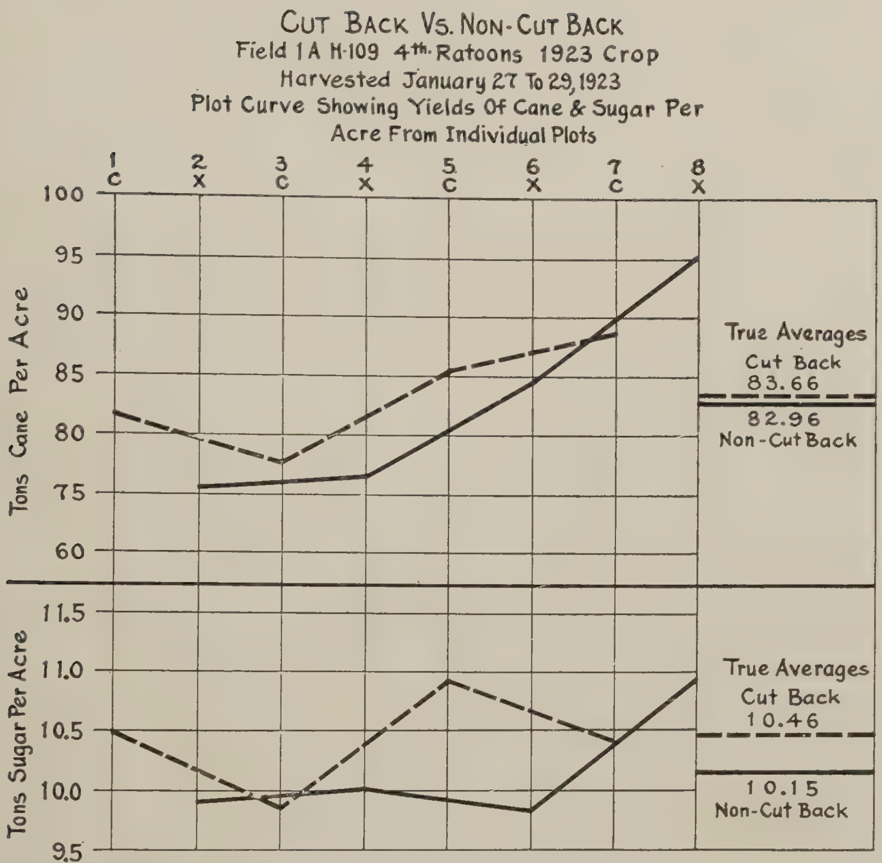


Fig. 3.

The loss for cutting back as shown by these average figures is corroborated by comparing the individual plot yields as shown by the plot curve (Fig. 4). There is no question about the increased yields due to non-cutting back.

While the stalks are very slightly larger in circumference for the non-cut-back plots, there are almost 5 per cent less stalks. The conclusion drawn is that longer stalks are responsible for increased yield. It is interesting to note that cutting back stimulated a great many shoots which were unable to continue growth so as to form stalk of cane which could be harvested. There was some mortality of shoots in the non-cut-back plots, but not as great as in the cut-back plots.

The quality ratio is consistently better for the cane that was not cut back, i. e., the older the cane the better the juice.

The previous crop was harvested on May 23, 1921, and the experiment was milled March 15, 1923. The alternate plots were cut back on July 6, 1921, and irrigated thereafter every 20 days. Weed growth immediately began to be very bad in the plots which were cut back. It required 36.3 per cent more labor to weed these plots as compared with the non-cut-back plots.

On August 19, 1921, the entire experiment received 645 lbs of nitrate of soda per acre (100 lbs. N.). On October 3, 1921, there was a 3-inch rain.

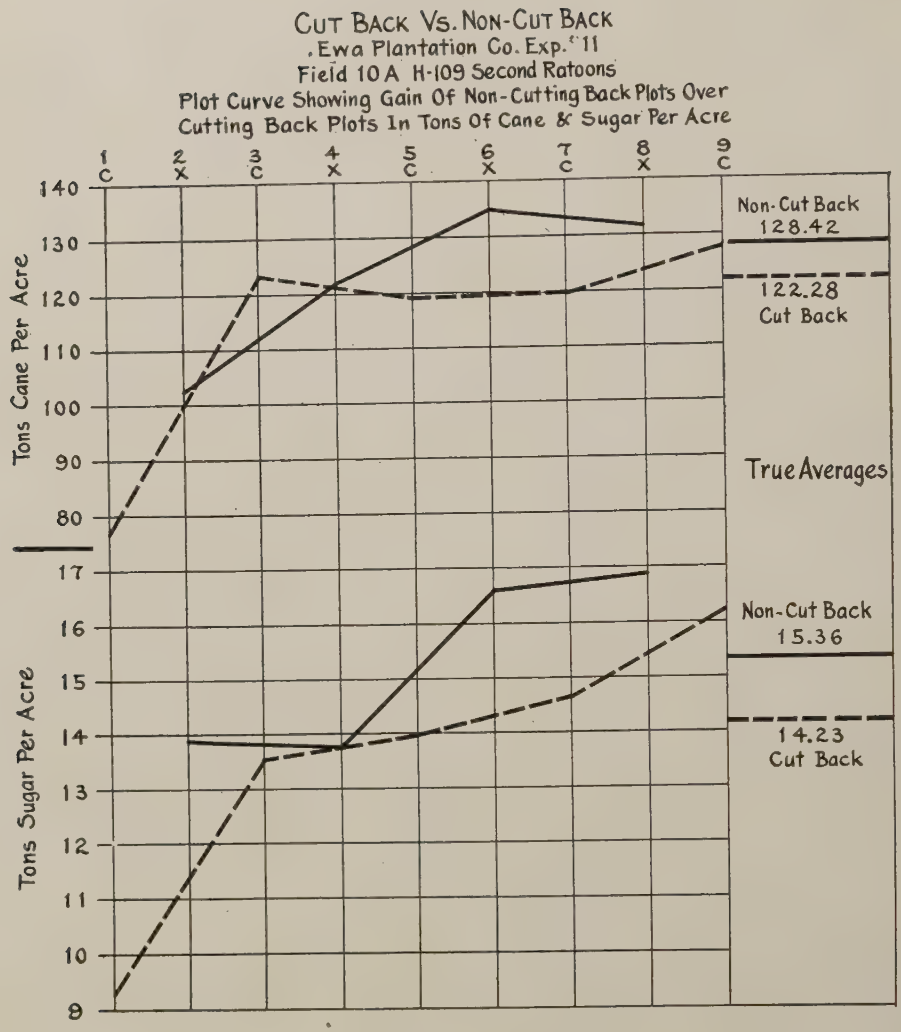


Fig. 4.

Not a single tassel appeared in either plots. Cane was growing very vigorously in the entire experiment, but in November it was noted that the cut-back plots contained a thicker growth than non-cut-back plots, although the cane was at least a foot higher in the check plots. Counts at this time showed almost 30 per cent more shoots or 50,791 shoots per acre in cut-back plots, as against 39,116 per acre in X plots. This extra growth did not reach maturity.

At harvest, trash on the ground was heavier on the cut-back plots, partly accounted for by the shoots that did not survive. The 30 per cent lead was cut down to one of less than 5 per cent, i. e., the cut-back plots had 23,805 stalks per acre as compared with 22,722 stalks in non-cut-back plots.

A second dose of 645 lbs. nitrate of soda per acre was made on March 1, 1922 (total 200 lbs. N.). Cane in both sets of plots made a splendid growth during the second season.

TABLE 4.

EWA PLANTATION COMPANY.

Field 10-A Cut-Back Experiment.

Harvesting Results, March 15, 1923. (Previous Crop Harvested May 23, 1921.)

Summary of Results.

Cut-Back

Plot	Treatment	Area	Tons Cane Total	Tons Cane per Acre	Total Tons Sugar	Tons Sugar per Acre	Q.R.	Pol. % Cane	Brix	Pol'n	Purity	P_2O_5	K_2O	Remarks
1	Cut-back	.096	7.3845	76.92	0.89	9.27	8.30	13.28	18.5	16.2	87.6	0.040	0.066	Ditch plot
3	"	.138	17.0675	123.68	1.876	13.59	9.10	12.22	17.2	14.9	86.6	0.040	0.091	
5	"	.108	12.929	119.71	1.512	14.00	8.55	12.79	17.6	15.6	88.6	0.030	0.093	Stand very poor
7	"	.066	7.9205	120.01	0.969	14.68	8.17	13.28	18.1	16.2	89.5	0.037	0.093	
9	"	.041	5.2465	127.96	0.667	16.27	7.86	13.78	18.7	16.8	89.8	0.032	0.074	
True Averages		.367	44.781	122.02	5.919	13.18	8.54	12.85	17.79	15.67	88.08	0.0358	0.083	
Omitting Plot 1		0.353	43.1635	122.28	5.025	14.23	8.59	12.78	17.67	15.58	88.17	0.0348	0.0878	

Non-Cut-Back

Plot	Treatment	Area	Tons Cane Total	Tons Cane per Acre	Total Tons Sugar	Tons Sugar per Acre	Q.R.	Pol. % Cane	Brix	Pol'n	Purity	P_2O_5	K_2O	Remarks
2	Non-cut-back	.091	9.337	102.60	1.267	13.92	7.37	14.51	19.3	17.7	91.6	0.045	0.056	Irregular plot
4	"	.129	15.745	122.05	1.783	13.82	8.83	12.55	17.6	15.3	86.9	0.035	0.109	
6	"	.089	12.023	135.09	1.477	16.59	8.14	13.28	18.0	16.2	89.9	0.035	0.113	
8	"	.058	7.676	132.34	0.98	16.90	7.83	13.78	18.6	16.8	90.3	0.032	0.126	
True Averages		.367	44.781	122.02	5.508	15.01	8.13	13.37	18.23	16.30	89.41	0.0368	0.101	
Omitting Plot 2		.276	35.444	128.42	4.24	15.36	8.36	13.06	17.95	15.93	88.75	0.034	0.116	

FIELD 19-B (H 109) SUMMARY AVERAGE YIELDS LAHAINA WITH H 109 REPLANT.

	Area	No. of Plots	Average Yields per Acre Cane	Quality Ratio	Sugar
Cut-back		5	88.03	7.94	11.09
Non-cut-back		5	94.91	7.77	12.21
Loss for cutting back............			6.88	.17	1.12

This test of old Lahaina ratoons, largely replanted with H 109, was small in total area, consisting of 10 plots of 8 lines (35 feet) each. Alternate plots were not cut back on July 8, 1921. The field had been harvested May 4, 1921, but had received practically no attention until after cutting back on August 8, 1921. All plots received 645 lbs. per acre of nitrate of soda. Rounds were about 25 days apart. There was no tasseling in the non-cut-back plots during the flowering season. The check plots at this time seemed to have a better growth than the cut-back plots. Plot yields are given in Table 5. While not consistently favoring non-cut-back, the general tendency is for better cane yields for the non-cut-back plots from 2 out of 3 plots.

There was made a composite cane sample in carload lots for each treatment and crusher juice of all plots obtained. The non-cut-back gave a quality ratio that was 2.26 per cent better.

The final gain in sugar produced, averaging all plots, therefore, was 10 per cent better for the plots that were not cut-back.

TABLE 5.

EWA PLANTATION COMPANY.

Field 19-B Cut-Back Experiment

Harvesting Results, December 23, 1922.

Cut-Back.

Plot	Area	Total Cane	Cane per Acre	Sugar per Acre	Quality Ratio	Brix	Pol.	Purity
1	.037	3.08	83.24					
3	.025	2.2975	91.90	Composited				
5	.029	2.1725	74.91					
7	.029	2.490	85.86					
9	.030	3.165	105.50					
	.150	13.205	88.03	11.09	7.94	20.4	17.3	84.8

Non-Cut-Back.

Plot	Area	Total Cane	Cane per Acre	Sugar per Acre	Quality Ratio	Brix	Pol.	Purity
2	.028	2.4225	86.52					
4	.025	2.23	89.20	Composited				
6	.026	2.195	84.42					
8	.031	3.3725	108.79					
10	.029	2.9725	102.50					
	.139	13.1925	94.91	12.21	7.77	20.6	17.6	85.4

Lupines for Green Manuring

Hamakua Mill Experiment 11, 1923 Crop.

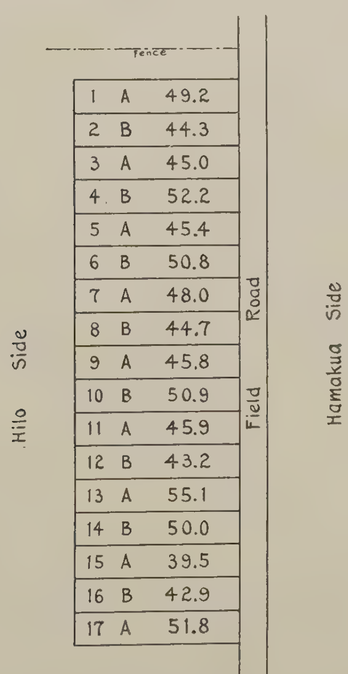
By J. A. Verret

Lupines (*Lupinus albus*) have been grown to some extent on the island of Hawaii as a green manuring crop. Of the cultivated legumes it is among those which make the best growth on that island. It has no value as a food crop, so its place in the agriculture of Hawaii would depend on its worth as a soil renovator.

Italian Lupines Vs. Natural Fallow

Hamakua Mill Co. Exp. 11, 1923 Crop

Field 17 A.



Summary of Results

Plots	No. of Plots	Treatment	Yields Per Acre		
			Cane	Q.R.	Sugar
A	9	Lupine	47.28	7.36	6.42
B	8	No Lupine	47.34	7.32	6.46

In order to get information upon this point an experiment was laid out at Hamakua Mill Co. The test comprised seventeen plots, each one-sixth acre, consisting of eight lines, 5 feet wide and 181.5 feet long. Nine plots were planted to lupines and eight were allowed to remain in natural fallow.

The lupines were planted in November, 1920, and came up well. On January 10, 1921, they were from 6 to 9 inches high. At that time the check plots had a light growth of pualele and oxalis. An examination of the lupine roots showed them well covered with nitrogen nodules. No nematode galls were found on the roots examined.

The lupines were plowed in on April 18, 1921. At that time they were about three feet high. Very few of the plants had flowered, as caterpillars got at them before they had a full chance to flower. The lupines in plots 1, 3 and 5 were practically dead, as the leaves had been eaten off.

Italian lupines growing at Pahala—three months old. (Photo by Hawaiian Agricultural Company.)

Weeds were not very thick in the no-lupine plots. When plowing in the lupines the other plots were also given the same treatment so as to eliminate cultivation as a factor in the results. The lupines were well covered.

The field was furrowed June 10, 1921, and planted to Yellow Caledonia June 11. At the time of furrowing the lupines had not completely rotted and a few of the larger stalks were pulled up. But this was only a small percentage of the total amount buried. All plots received uniform fertilization according to plantation practice for plant cane.

The experiment was harvested July 12, 1923. The juices were sampled by Mr. Murray in carload lots.

The results show no advantage for the lupine plots, as indicated below:

Treatment	Yield per Acre Cane	Q. R.	Sugar
Lupines	47.3	7.36	6.42
No lupines	47.3	7.32	6.46

The Station does not advocate the use of lupines for green manuring purposes. We believe it is more profitable to the plantations to allow natural growth to take place on the fallow fields and to pasture stock on them. This entails no expense and furnishes feed for cattle and gets some benefit from the manure produced.

The above test will be continued for another crop to note if there is any residual or delayed action from the material plowed under.

Details of Experiment

Green Soiling

Object—

Comparing legumes with no legumes.
The legume was Italian Lupines (*Lupinus albus*).

Location—

Hamakua Mill Company, Field 17-A.

Crop—

Yellow Caledonia, plant, planted June, 1921.

Layout—

17 plots, each 1/6 acre, consisting of 8 lines each, 5 feet wide and 181.5 feet long.

Plan—

9-A plots Lupines;
8-B plots no Lupines;
Fertilization—Uniform by plantation.
Experiment harvested by Mr. J. S. B. Pratt, Jr., with the help of the plantation.
Cane sampled in carload lots by Mr. Murray, the plantation chemist.

Iron, Aluminum and Manganese in the Soil Solution of Hawaiian Soils

By W. T. McGeorge.

In a recent study of the methods of estimating and detecting acidity in Hawaiian soils (12) facts were noted strongly indicating the salts of iron, aluminum and manganese to be involved.

Until recently the presence of free acid in acid soils was the only factor considered to be involved in their low fertility. In 1913 Abbott, Conner and Smalley (1) published results showing a definite relation between low root vitality of corn and soil reaction. They found associated with this high acidity comparatively large amounts of soluble iron and aluminum salts. This work has been the incentive for numerous other investigations which have led to the suggestion that the toxicity of aluminum and manganese salts soluble in acid soils is of greater import than the hydrogen ion concentration itself. The toxicity of alkali soils has long been attributed to the high concentration of certain alkali salts. It is interesting to note the more recent trend of soil acidity interpretations on the basis of injuriously high concentrations of acid reacting salts.

In examining acid Hawaiian soils, the main characteristic, as in other acid types, is the absence of easily soluble bases calcium and magnesium and soluble phoshpates. Such conditions are conducive toward the accumulation of acid reacting salts of iron, aluminum and manganese with free hydrogen ions formed by their hydrolysis in aqueous solutions. This in spite of the comparatively high base and low silica content of Hawaiian soils.

In view of the recognized toxicity of certain concentrations of these salts in the soil solution a further study of the nature of these existent compounds in our soils seemed imperative. Both sugar cane and pineapples, the principal commercial crops of the Islands, have shown positive evidences of low root vitality on some of the highly acid Island soils.

Occurrence.

Aluminum: Aluminum occurs in Island soils chiefly as the phosphate, hydrate, oxide and silicate, the two latter compounds being also present in hydrated forms. It is the most abundant basic element. In both the lava and volcanic ash, aluminum is far in excess of iron and manganese and almost equal to the silica content if expressed as the oxide, Al_2O_3. During the process of disintegration the per cent aluminum in the residual products is greatly increased and still in large excess over all other elements except silica. On the basis of 30 per cent Al_2O_3 and calculated on the basis of 3,000,000 pounds soil per acre foot there is present 900,000 pounds alumina per acre. It is present in largest amounts in the clay and fine silt particles, but even in the coarses particles is often in excess of 20 per cent.

There appears to be some diversity of opinion as to the occurrence of aluminum hydrates in mainland soils. In fact this applies generally to all temperate climates where environment induces kaolinization rather than laterization. Mirasol (13) has concluded, however, from a review of the literature that evidence indicates their presence in some mainland soils. The three recognized hydrates of aluminum are: Diaspore Al_2O_3 H_2O, Bauxite Al_2O_3 $2H_2O$, and Gibbsite Al_2O_3 $3H_2O$. The two former are insoluble in dilute acids, alkalis and water, while Gibbsite is soluble in dilute acids and alkalis but insoluble in water. We therefore look upon the latter as the principal source of soluble aluminum. In applying these facts and theories to Island conditions it is significant that in our yellow soils, which are in a higher state of hydration, and in other types which are high in water of hydration, aluminum is present in larger quantities soluble in dilute acids. Tropical environment, which is known to induce a higher concentration of Gibbsite in the residual products of disintegration is also existent. Evidence therefore strongly indicates the presence of this hydrate in a large percentage of our Island soils.

We also have strong evidence of the presence of aluminum silicates and alumino-silicic acids which are more or less soluble in water and by dissociation the latter will yield hydrogen ions to a small degree. We have present therefore a large reserve of potential acidity.

Iron: Iron, like aluminum, occurs chiefly as silicate, oxide (principally ferric oxide) and hydroxide. The ion content of the lava and volcanic ash is much lower than aluminum and approximately equal to the lime and magnesia, usually being about 10 per cent. It is greatly increased in the residual products of disintegration but is still much lower than the aluminum content of the soil. The soluble salts of ferric iron are much less stable than those of aluminum, their hydrolysis and precipitation being, under soil conditions, proportionately more rapid. In our highly puddled and poorly aerated soils ferrous salts are usually present in varying amounts.

Manganese: Manganese occurs chiefly as the silicate and oxide widely scattered in all soil types in amounts varying from a few tenths of a per cent to 10 per cent. It is present in the lava and volcanic ash in only small amounts, being rarely as high as 1 per cent and usually about .5 per cent. During the process of disintegration it appears to be readily dissolved, and that present in the residual products is greatly reduced by weathering agents. For this reason the Island soils are proportionately lower in manganese than the lava, except in certain isolated lower areas of the aluvium where soluble manganese salts have accumulated and precipitated as the dioxide, often as high as 10 per cent.

Veitch (16) in a study of the Hopkins method of determining soil acidity was probably the first to call attention to the role of aluminum salts in acid soils. He noted the presence of aluminum in the extract obtained by shaking an acid soil with a solution of potassium nitrate. This solution of aluminum was attributed to the replacement of aluminum by potassium in the alumino silicates. Parker (14) concludes that this solution is due to a side reaction and the solvent action of acid formed by the selective absorption of the basic ion of the salt solution. Additional theories of the source of soluble aluminum in the soil solu-

tion involve that of Ames and Boltz (2), who attribute its solution to the acidity resulting from sulphofication, and that of Abbott, Conner and Smalley (1), who suggest the formation of aluminum nitrate in the absence of adequate lime to neutralize the nitrate formed during nitrification. On the other hand we note that Denison (7) failed to identify soluble (crystaloidal) salts of aluminum in soil extracts, but did establish the presence of the hydrosol aluminum hydrate. Knight (12) also arrives at the same conclusion. Both question the formation of soluble salts of these elements in many acid soils.

The above contradictions suggested that we clarify some of these questionable points in Hawaiian soils and definitely determine the hydrogen ion concentration at which we can have a reasonable assurance of the presence or absence of the salts of these elements. In view of the apparent relation between some types of root-rot and soil acidity it is highly essential to be able to recognize more definitely the soil types in which this association is possible. So-called root-rot of sugar cane in Hawaii is not confined entirely to acid soils.

Experimental.

The logical procedure in the separation of colloid from crystaloid compounds involves the utilization of a semipermeable membrane. The plan of the experiment was therefore as follows: A definite selection of soils was made to cover a number of characteristic types. The soil solution itself as well as a salt solution extract were prepared and dialyzed for a definite period and the resultant changes in the soil solution determined.

Choice of Soils.

No. 1. A yellowish brown silty clay loam from Kaneohe district, island of Oahu. Pineapple plants badly wilted, sugar cane had previously failed.

No. 2. A brown silty clay loam from Kaneohe district, island of Oahu. Pineapple plants badly wilted, sugar cane had previously failed.

No. 3. A bluish grey adobe soil, Waimanalo district, island of Oahu. A low poorly drained soil on which a resistant cane variety grows well.

No. 4. A dark grey sandy loam, highly organic, from Honokaa, island of Hawaii. Sugar cane root vitality very low.

No. 5. A dark grey sandy loam, highly organic, from Honokaa, island of Hawaii. Growth of cane only fair.

No. 6. A chocolate brown silty loam, highly manganiferous (7 per cent MnO_2). No indication of poor root growth.

No. 7. A dark clay loam, from Experiment Station plots, Honolulu. Good root growth.

No. 8. A black clay soil from Waimanalo, Oahu, similar to No. 3, but sufficiently impregnated with lime to make alkaline.

Experiment 1.

Potassium Nitrate Extracts.

Four hundred grams of soil were shaken, with one litre of a normal solution of KNO_3, continuously for three hours in an end-over-end shaking machine. Two hundred and fifty cc. aliquots of this filtrate were used for analysis. One was analyzed direct while the other was placed in a pyralodion sack. The sack and contents were suspended in an 800 cc. beaker, distilled water added to a level above that of the solution within the sack and the whole placed in a water bath. This bath was maintained at a temperature of 45° C. and the water in the beakers changed daily for a period of two weeks. At the end of this time the solution remaining in the dialyzing sack was subjected to the same analytical procedure as the original extract. The results are given in the following table:

TABLE 1.

Showing Analysis of KNO_3 Extracts Before and After Dialysis Results as Per Cent.

		Original Extract				Non-Diffusible Extract			
Soil No.	P H	SiO_2	Fe_2O_3 Al_2O_3	Mn_3O_4	CaO	SiO_2	Al_2O_3 Fe_2O_3	Mn_3O_4	CaO
1	4.46	.0043	.0809	+	.0350	.0020	.0030	—	—
2	4.46	.0045	.0106	+	.0443	.0000	.0015	—	—
3	4.93	.0115	.0199	+	.4480	.0000	.0015	—	—
4	5.39	.0020	.0019	+	.1129	.0000	.0004	—	—
5	5.98	.0045	.0027	—	.1806	.0000	.0017	—	—
6	6.00	.0110	.0018	—	.2422	.0009	.0015	—	—
7	7.76	.0050	.0018	—	.3794	.0029	.0012	—	—
8	7.90	.0023	.0016	—	.6230	.0000	.0016	—	—

All extracts were evaporated to dryness on the steam bath and heated in the hot air oven at 120° C. to dehydrate the silica. The acid insoluble residue from this operation was weighed as silica. Iron and aulminum were determined together as phosphates and precipitated in the presence of acetic acid in order to avoid calcium contamination. Manganese was not determined quantitatively.

The results definitely prove the presence of crystaloid forms of iron aluminum and manganese in all the soils below pH 5.9 and indicate that above pH 6.0 only the hydrosol forms are present, while the manganese is entirely absent. This in spite of the fact that soil No. 6 contains 7 per cent MnO_2. Dialysible forms of silica are present in all the soils, there being little or no colloid forms present in solution. Manganese and calcium are present entirely in dialysible forms.

In addition to the data given in Table 1 titrations of the KNO_3 extracts were also made on the original extract and the contents of the paralodion sacks after dialyzing for two weeks. In this titration 125 cc. was boiled for ten minutes and then titrated with .2 N KOH using phenolpthalein as an indicator. All the extracts within the paralodion sacks were practically neutral. The titration in cc. .2 N KOH are given in Table 2.

+ Present but not determined quantitatively; — not present.

TABLE 2.

Showing Titration of KNO_3 Extracts as cc. .2 N KOH per 125 cc.

Soil No.	Original Extract	Non-Diffusible Extract
1	6.00	neutral
2	1.10	neutral
3	2.60	0.05
4	0.80	neutral
5	0.60	neutral
6	0.10	0.10
7	alkaline	0.10
8	alkaline	neutral

These results definitely show the acid or acid salts present in the KNO_3 extracts to be present in a form which will penetrate a semipermeable membrane in entirety.

Experiment 2.

The soil solution was next obtained from this same set of soils and dialyzed according to the following procedure. Five ponnds of soil were added to each of 5 glass percolators, distilled water added to saturation and the whole allowed to stand for 48 hours. They were then treated by the displacement method as outlined by Parker (14) which had previously been shown to yield the actual soil solution when applied to Hawaiian soils. In this case distilled water was used as a displacing liquid. The first 200 cc. of percolate was collected from each giving one litre total. Two hundred and fifty cc. of this soil solution was placed in paralodion sacks and dialyzed as described in Experiment 1. The remaining 750 cc. was analyzed direct. The results are given in Table 3, expressed in milligrams per litre of the solution. It should be mentioned that this solution is probably less concentrated than the actual soil solution owing to the addition of water up to the point of saturation, but the results are comparable and serve well for determining the diffusibility of the components of the soil solution.

TABLE 3.

Showing Analysis of Soil Solution Before and After Dialysis, as Mgs. per Litre.

	Original Soil Solution					Non-Diffusible Solution			
Soil No.	pH	SiO_2	Fe_2O_3 Al_2O_3	Mn_3O_4	CaO	SiO_2	Fe_2O_3 Al_2O_3	Mn_3O_4	CaO
1	4.46	3.6	7.2	0.8	30.9	0.8	1.6	—	—
2	4.46	10.5	15.1	18.3	116.9	0.8	4.4	—	—
3	4.93	66.5	10.0	4.0	117.2	0.8	1.2	—	—
4	5.39	19.1	8.2	3.3	550.4	0.4	3.2	—	—
5	6.00	16.5	0.8	0.0	29.6	not det.	not det.	—	—
7	7.76	27.7	4.0	0.0	91.1	2.0	3.6	—	—
8	7.90	41.2	3.7	0.0	274.4	0.4	3.6	—	—

— Not present.

These results compare very closely with those obtained by extracting the soil with KNO_3 solution. The iron and aluminum are present in largest part in the crystaloid form in all the soils of pH 5.5 or less while the manganese was not present in the soil solution above pH 5.9.

Discussion.

In view of the results obtained in the preceding experiments it is interesting to compare with similar investigations. Knight (12) in a study of the Hopkins method, subjected the KNO_3 extract to dialysis in a collodion sack. In his experiments 74 per cent of the titratible acidity passed through the membrane but no aluminum. All the latter remained in the collodion sack, showing it present entirely in colloid form. The pH of his soil is not given, but it showed a higher titratible acidity than any used in these experiments. Similarly Denison (7) in leaching several Illinois soils with normal KNO_3 solution obtained no dialysible aluminum salts. Therefore he concludes a single treatment of the soil with KNO_3 solution yields only the hydrosol aluminum hydrate. On percolating water through this soil he was unable to obtain a test for alminum from five litres of percolate. Unfortunately, he does not give the pH of the acid soils used.

On the other hand, Mirasol (13) found that by leaching acid soils with normal KNO_3 solution he was able to remove a large per cent of the iron, aluminum and manganese salts and effect a corresponding reduction in acidity. Similarly, with water he noted a marked reduction of acidity corresponding with the removal of soluble salts of the above elements. His work has been severely criticized in view of the fact that he based his conclusions on the analysis of the soil before and after treatment. He therefore failed to distinguish definitely between colloid and crystaloid forms and did not actually demonstrate the presence of soluble salts.

Abbott, Conner and Smalley (1) determined the aluminum in the leachings from an acid soil in which corn roots were badly rotted, but did not distinguish between crystaloid and colloid, assuming the former. Hartwell and Pember (9) did not analyze the soil extracts, but determined the toxicity of diffusible and non-diffusible portions. Ruprecht (15) found iron and aluminum salts in acid soils of low fertility after filtering through unglazed porcelain. Blair and Prince (3) have also determined iron and aluminum in water extracts of acid soils without attempting to distinguish between crystaloid and colloid forms.

It is evident from the above that there is more or less difference of opinion as to the forms in which iron and aluminum salts are present in the soil solution, and some positive results supporting the non-existence of crystaloid forms.

From the data given in Tables 1 and 3 coupled with other observations it may be definitely stated that all Hawaiian soils of pH below a point between 5.5 and 6.0, believed by the writer to be 5.8, contain soluble salts of iron, aluminum and manganese. Whether toxic toward plant growth will depend upon associated environment, more especially the available phosphates present in the soil.

It is hardly believed from the results thus far obtained that soluble iron salts are a factor. While no attempt has been made in the analysis of the soil extracts to separate iron and aluminum it was possible to judge from the color

of the precipitate the relative amounts present. Aluminum was present in excess in every case. Iron salts hydrolyze more rapidly under soil conditions and precipitate as $Fe(OH)_3$. It may be of interest to state that in attempting to prepare nutrient cultures for studying the toxicity of iron salts, it was found impossible to keep iron in solution even at a concentration of N/5000. These facts strongly indicate the minor role which iron must play in any toxicity of our acid soils. This refers only to ferric salts. Frequent instances have been noted in Island soils where puddled and poorly aerated areas have been found to contain appreciable amounts of ferrous iron. Such soils are usually characterized by a bluish grey color.

Of the soluble salts found associated with acid soils aluminum has been found to be the most toxic and for this reason the reduced growth of many plants on such soils has been attributed to the presence of salts of this element in the soil solution. In our highly organic soils the aluminum appears to be present in large measure as organic salts of high potential yet low intensive acidity. The solubility in dilute acids is very high, with comparatively low solubility in water. Burgess (4) has published a method for the determination of aluminum in which he classifies that soluble in .5 N acetic acid as "active", Applying this method to Hawaiian soils some have been noted as over 2,000 p.p. mil. while an even higher content of active iron has been noted in highly puddled soils. Analytical evidence therefore strongly indicates the presence of toxic amounts of aluminum in many of our acid soils.

The solubility of manganese is of special interest in its relation to the chlorotic condition of pineapple plants and the absence of chlorosis of sugar cane grown on the manganiferous types. The principal physiological disturbance is, according to Kelley (11), due to an abnormal absorption of calcium by the plants grown on the manganiferous soils, while Johnson (10) claims a toxic effect from manganese. No manganese soils have been noted by the writer with a pH below 5.9 and no manganese has been found present in the soil solution at this pH or higher. Soil number 6 is a typical manganiferous type. The theory advanced by Kelley (11) suggesting the higher assimilation of calcium appears the more tenable, sugar cane having a greater tolerance for calcium. The lower acidity which is typical of the manganiferous type and below the hydrogen ion concentration at which manganese salts have been found present in the soil solution and the greater absorption of calcium by plants on this soil type, makes the toxicity of manganese appear less tenable at this reaction. This does not deny the toxicity of manganese salts but merely points out their absence in the soil solution of this soil type. If manganese does exert a direct toxic effect as noted by Johnson (10) with pineapples grown in water cultures, we must associate this with soils of higher acidity in which their presence is definitely shown by the data in Tables 1 and 3. The influence of this factor on the growth of sugar cane is now being studied. Thus far there has been no evidence of any injurious nutritional disturbance with sugar cane grown on manganiferous soils. There is also no evidence of so-called root-rot of pineapples on the manganese soils, but only a chlorotic condition of the leaves attributed as above to the abnormal assimilation of calcium. There is, however, positive evidence of low root vitality

of both sugar cane and pineapples on some acid soils. All the soils of pH 5.5 or lower contain appreciable amounts of manganese in solution and it is not unreasonable to suspect a certain degree of toxicity on such types.

Carr (5), in studying the relation of manganese to soil acidity or toxicity, which terms he suggests as synonymous, claims the presence of soluble manganese up to a pH of 7.9. He bases his conclusions upon the work of Greenfield and Buswell (8) and the results obtained by himself, using the Comber method of testing for soil acidity. The former studied the precipitation of manganese as hydroxide using a fixed alkali, sodium hydroxide, and found precipitation complete only at pH 7.9. That this does not hold true under soil conditions is shown by the results given in Tables 1 and 3. Manganese soils in Hawaii are usually found in localized areas formed by the deposition of manganese as dioxide. Evidence indicates it to be present in the lavas in a form easily dissolved by the agents of disintegration. It is therefore precipitated at a pH far below 7.9 if we are justified in accepting the present pH of these soils as a criterion. This high concentration of manganese dioxide in localized areas and the absence of manganese in the soil solution of the soils above pH 6.0 may be attributed to the precipitation by lime at this pH range or the formation of manganic salts which being of extremely low stability will not remain in solution.

Comber (6) found that on shaking an acid soil with an alcoholic solution of KSCN he obtained a red color, ferric sulphocyanate, and suggested the use of this reagent in testing the soil reaction. Carr (5) in a study of this method noted the formation of a green color which he attributed to the presence of soluble manganese.

The writer has also obtained this green color with all soils of pH 5.5 to 7.0 and most soils above 7.0. Among the soils which Carr examined was a highly manganiferous sample from Hawaii in which he claims the presence of soluble manganese basing his conclusions on the green color obtained by the Comber test. While he does not state the pH of this soil it seems reasonable to assume that it is of approximately 5.9 or higher in view of the fact that the writer has failed to find a sample of this type below this figure. Being at a loss to explain Carr's conclusions after having failed to find soluble manganese in soils of this type and reaction some attention has been given to a study of this point.

Most Hawaiian soils contain at least .5 per cent manganese dioxide and will range from this up to 10 per cent. A soil of pH 5.5 or higher regardless of the amount of manganese dioxide present usually gives a greenish blue color, not immediately but only on standing, by the Comber method using ethyl alcohol as the solvent. Soils of pH 5.5 or less will retain their original red color. The writer believes, although it has not been absolutely proven, that there is strong evidence that this green color is due to the formation of manganese perchloride ($MnCl_4$). This suggestion is based upon a brief study of this color development, the fact that manganese is present in our soils principally as MnO_2 the anhydride of tetravalent manganese hydroxide ($Mn(OH)_4$) and further that manganese tetrachloride is one of the very few green manganese salts soluble in alcohol.

In determining why the green color, which appeared to be associated with the presence of manganese, is obtained with soils containing no soluble manganese

it was necessary to recognize the results given in Tables 1 and 3 showing no soluble manganese or other acid salts in the soils of pH 6.0 or higher in the KNO_3 extracts. That is, there was no displacement with potassium nitrate under the conditions of this method.

In treating a manganiferous soil containing 10 per cent MnO_2 by the Comber method a faint pink color was obtained, as usually noted, fading to colorless and finally to greenish blue on shaking several times and allowing to stand. The original pH of this soil was 6.3, which on shaking with alcoholic KSCN dropped to pH 5.5, which is within the range at which manganese salts are in solution. In order to obtain further data on the increase in hydrogen ion concentration when shaken with this reagent, a series of soils was selected varying in pH from 4.4 to 8.0. These soils were shaken with alcoholic KSCN in the proportion of one part soil to two parts 5 per cent KSCN in alcohol and the pH of the mixtures determined immediately and at intervals up to 24 hours. In all soils of pH 5.9 or higher the pH dropped to 5.5 and gradually changed to a greenish blue color. In the more acid soils the pH dropped considerably below 5.4 and all these retained their red color. In other words, the soluble manganese which Carr found is not actually present in the soil solution as such but is made soluble by the higher hydrogen ion concentration. On adding an excess of MnO_2 to the alcoholic extracts of all the soils which retain their red color the hydrogen ion concentration will lower rapidly to a pH of 5.5 or slightly higher, discharging the red color. The color therefore appears to be a function of the hydrogen ion concentration. This is further indicated by the fact that a filtered Comber extract which is green will change to a red color on slightly increasing the hydrogen ion concentration.

Conclusions.

The preceding data and discussion covering a study of typical soils from areas on which root-rot of pineapples and sugar cane is or is not existent strongly indicates the toxic compounds associated with acid soils to be related to the reduced plant growth on such areas. The role which the salts of aluminum and manganese play is not clearly understood, although the association of phosphate starvation is apparent. This point is being studied in water, sand and soil cultures involving first the toxicity of aluminum and later based on the data submitted in this paper, the toxicity of manganese salts and aluminates. Preliminary experiments have already shown a marked toxic effect of aluminum salts toward sugar cane. It is therefore not unreasonable to assume a definite relation between the presence of aluminum salts and possibly manganese in our highly acid soils and low root vitality which we find present on the cane and pineapple plants grown on such areas.

But we cannot explain by the above theories the root-rot which eliminated the Lahaina cane from the coral lands of Oahu, Ewa and Honolulu plantations. The reaction of these soils is approximately pH 8.0 and they are usually high in available phosphate, the very environment in which aluminum salts are not present. The only possibility of aluminum being a factor, in such soils, is the presence of aluminates which appears to be only vaguely tenable. Blum has

shown that in precipitating aluminum salts with a fixed alkali precipitation is complete between pH 6.5 and 7.5. From 7.5 to 8.0 or higher aluminum will redissolve as the aluminate (i. e., Na_2AlO_2), the sodium and potassium salts being very soluble in water. The calcium salts are, however, very insoluble. The theoretical possibility of soluble aluminates is therefore evident in alkaline soils. The amphoteric nature of aluminum hydrate introduces complications which cannot be ignored and would theoretically permit the presence of aluminates. We must further recognize the ability of plants to feed on apparently insoluble minerals, although there is no evidence to indicate the assimilation of toxic amounts from such sources. The latter applies to manganese and iron as well as aluminum.

Summary.

1. Normal potassium nitrate does not displace the aluminum in aluminum silicates except in those soils of pH below 6.0.

2. Soluble crystaloid salts of iron, aluminum and manganese were found only in those soils of hydrogen ion concentration below 5.8.

3. At pH 6.0 or above manganese is not present in the soil solution and iron and aluminum only as the hydrosols of ferric and aluminum hydrates.

4. The solubility of manganese as indicated by the Comber test is due to the lower pH developed on shaking a soil with alcoholic potassium sulphocyanate.

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Chlorid of Lime as a Soil Disinfectant*

By Dr. Oscar Loew.

Among the media serving as soil disinfectants thus far only bisulfid of carbon and carbolineum are sufficiently low in price for practical purposes. I found, however, some years ago that chlorid of lime is just as effective and considerably cheaper.

Chlorid of lime is generally considered as a mixture of calcium chlorido-hypochlorite $Ca \begin{matrix} Cl \\ = O.Cl \end{matrix}$ with calcium hydroxid. By its decomposition in contact with carbon dioxid chlorin is set free, $Ca \begin{matrix} Cl \\ = O.Cl \end{matrix} + CO_2 = CaCO_3 + Cl_2$. This free chlorin will spread in the soil to which chlorid of lime has been applied and kill all sorts of animal and vegetable organisms. Only certain bacteria and spores will resist, and then when the chlorin is not too concentrated. A loam soil poor in humus was given 300 grams of chlorid of lime per square meter mixed uniformly to the depth of about 10 centimeters. After five days it was found that the denitrifying bacteria had decreased to mere traces, the "desulphurization" bacteria had been entirely annihilated and the butyric bacilli had decreased to about one-third of the original number, probably due to their resistant spores.

The killed organisms will yield up their mineral nutrients and nitrogenous compounds furnishing ammonia for the roots of the plants grown there later on, after the chlorin is either volatilized or transformed into hydrochloric acid. This latter acts again on calcium carbonate of the soil with the production of calcium chlorid.

The more organic matter like humus contained in a soil, the more rapidly the free chlorin will pass by causing oxidations into hydrochloric acid and this into chlorids. On the other hand a high content of clay may delay the destruction of the chlorid of lime by enclosing particles of it and preventing the access of carbon dioxid contained in the pores of the soil. Thus it can easily be understood that the time for the destruction of the chlorid of lime may vary from eight days to two months, as was shown by tests with potassium iodide and starch upon the aqeous acidulated extract of the soils.

An application of 100-200 grams of chlorid of lime to the square meter will suffice on ordinary soils, while at least 300 grams will be required on soils infected with parasitic nematodes, fungi and injurious microbes. In some cases it will be found preferable to treat the chlorid of lime with about 10 times its weight of water and to apply only the supernatant liquid to the soil, while the sediment of calcium hydroxid or slaked lime may be used elsewhere. Care should be taken in handling the chlorid of lime, as it will attack skin, eyes and lungs.

The following described experiments were made on tired soils which were continuously planted to the same crop and also on healthy soils:

* From a circular of the Porto Rico Experiment Station.

1. On the lily beds of a Botanic Garden the development of *Lilium Candidum* went from bad to worse. The leaves turned yellowish and the number of flowers decreased from year to year, although some change of the soil in the bed was made by renewing it. The roots died off gradually and underwent putrefaction. Noxious insects and nematodes were not discovered on the roots. Of this bed five lots 1.5 square meters each were used for the experiments. No. 1 served as control, 2 received 100 grams of chlorid of lime; 3 potassium permanganate, 110 grams, dissolved in 5 litres of water; 4 tricresol, 30 grams, suspended in 5 litres of water; 5 bisulfid of carbon, applied in five holes of 20 cm. depth which were closed and the soil was well watered.

Six weeks after these applications an equal number of tubers of *Lilium Candidum* 20 cm. high were transplanted from the culture pots upon these five lots. After two months development the following results were observed:

Treatment	Number of Stems	Number of Flower Buds	Height of Stems (Average) cm.
Control	4	18	69
Chlorid of lime	8	55	90
Permanganate	6	31	65
Tricresol	7	39	62
Bisulfid of carbon	5	35	67

As noted the chlorid of lime produced the best results.

2. In a vegetable garden a steady decrease of the harvest of cabbage and radish was observed. We treated one of the beds with 300 grams of chlorid of lime per square meter. Three weeks later cabbage was planted. At harvest time every plant was found healthy, while on the control bed the usual injury was evident.

3. In a commercial flower garden several beds had become very unproductive in spite of rich manuring. Young violets and carnations, also young poplar trees, gradually withered and died. My investigation revealed the presence of nematodes. On lots of 4 square meters each the following treatments were applied:

1. Chlorid of lime, 500 grams, mixed with the soil which was then well watered. 2. Carbolineum, 500 grams, mixed with 4 litres dry peat soil then well worked into the ground. 3. Bisulfid of carbon, 500 grams, applied to five holes which were then filled up with earth and well watered. 4. Served as control.

Three weeks later 160 aster plants were transplanted from the seed bed. On three plots on the carbolineum plot the planting took place six weeks later. Two months afterwards the number of dead plants were counted with the following results:

On the bed of chlorid of lime	3.8%
On the bed of carbolineum	3.1%
On the bed of bisulphid of carbon	22.5%
On the control bed	34.4%

It will be noticed that chlorid of lime surpassed the carbon bisulfid considerably in effectiveness.

4. On a loam soil very well manured with compost and apparently normal and healthy, chlorid of lime was applied at the ratio of 200 grams per square meter. Each lot measured 6 square meters. A second lot received the equivalent amount of calcium carbonate, while a third lot served as control. Cabbage and beets were planted two months later upon these lots, and equal number on each. On another field (loam soil) potatoes were planted on lots of 9 square meters each. The yields are shown in the following table:

	Chlorid of Lime	Carbonate of Lime	Control
Cabbage	13.6 Kg.	8.9 Kg.	10.4 Kg.
Beets	54.8 "	31.1 "	33.0 "
Potato (2 lots each)..........	21.3 "	41.9 "	12.1 "

It will be noted that in all these cases the chlorid of lime treatment was very satisfactory. It was especially striking that the lots treated with chlorid of lime had remained free from undesirable weeds, in contrast to the other lots, and that the potato leaves excelled in their deep green coloration.

These experiments indicate that agriculture may derive considerable advantage from the judicious and proper application of chlorid of lime.

Reviews

Field Control of Tomato Mosaic, by Max W. Gardner and James B. Kendrick, In Phytopathology, Vol. 13, No. 8, August, 1923, p. 372.

Tomato plants are subject to a mosaic disease of a similar character to the mosaic disease of sugar cane. The authors of this article have pointed out the importance of perennial weeds as winter carriers of mosaic disease of the tomato and recommended the eradication of such weeds as the ground cherries, *Physalis subglabrata, P. virginiana* and *P. heterophylla* and the horse nettle, *Solanum carolinense* with the idea of removing the sources for infection from fields for tomato planting. To test out this recommendation the following experiment was undertaken:

Young tomato plants were obtained from virgin plant beds carefully protected to insure all plants in the experiment being free from the disease at the outset. Three separate fields were planted with these mosaic-free plants; field 1 of 10 acres, field 2 of 5 acres, and field 3 of 30 acres. In fields 1 and 2, a vigorous effort was made to keep down the weeds while field 3 was used as a control and weeds were allowed to appear, although the ordinary cultivation methods in field practice were followed. Fields 2 and 3 were planted during the third week in May and field 1, 2 weeks later.

On May 29 *Physalis* was appearing in and around all fields and fields 1 and 2 were weeded. A week later another weeding was necessary and thereafter

at approximately one week intervals until late in July in Field 2 and early August in Field 1. In Field 3 *Physalis* appeared but no special effort was made to combat it other than the usual horse cultivation.

On August 29 a count of affected plants was made in all fields with the following results:

	Number of Plants Examined	Percentage Mosaic Plants
Field 1 weeded	6,400	0.43
Field 2 weeded	3,600	1.80
Field 3 control	1,720	14.20

The authors conclude that entire freedom of the plant beds, and early efforts at weed control in the field greatly aid in minimizing mosaic disease in tomatoes.

The suggestions arising from a review of the foregoing experiment would be to have a number of replications of both weeded and control fields since the difference in percentage of mosaic plants recorded in the above experiment might easily have occurred through chance. Moreover it is apparent that in the control field, number 3, a complete count of plants was omitted, so that unless the methods for the count were described, some doubt might exist as to figures being representative.

There is very evidently a suggestion of possible value in mosaic disease control in sugar cane, resulting from this paper, however. It would seem desirable to follow up this suggestion by careful weed control experiments following planting until the cane has shaded in.

H. A. L.

Zinc in Boilers*

An inquiry regarding the use of zinc in boilers addressed to the Boiler Code Committee of the American Society of Mechanical Engineers brought out the following statement from the subcommittee on the Care of Steam Boilers and Other Pressure Vessels in Service, of which F. M. Gibson is chairman:

Zinc is used in boilers for two reasons—the prevention of scale and the prevention of corrosion.

As a preventive of scale there is conflicting evidence of its value. In some cases it is positively harmful and should be used with caution. Where it can be used safely, the same results can be obtained more positively by the means of feed-water treatment. It is of most benefit in selenitic waters, also where the scale consists of organic matter and lime and where sulphates and chlorides are in excess over carbonates. If only organic matter is present in the water, and zinc is used, a hard scale is formed which frequently causes over-heating. Carbonate of lime, carbonate of magnesium or carbonate of iron quickly renders

* Power, Vol. 58, No. 6.

the zinc brittle and porous and reduces it to powder. Zinc should not be used where feed-water compounds are used.

As a preventive of corrosion the use of zinc has been successful where there existed electrolytic action, air in feed-water or hydrochloric acid evolved from chloride of magnesium in sea water. Where used to counteract the action of air in feed-water, it should be placed near the entrance of the feed.

Zinc should be used only upon the advice of a chemist who is familiar with feed-water treatment.

The amount of zinc to be installed depends upon the conditions involved and ranges from 0.5 to 1.0 square foot of exposed surface, not including edges, to each 100 square feet of heating surface.

Zinc slabs should be made of one-half inch thick rolled plates and should be in good electrical connection with the metal of the boiler by means of copper wire or other good conductor of low electrical resistance. Where straps are used to hold the zinc in place, they should be filed bright where in contact with zinc and boiler material; after being bolted in place, the outside joints should be protected with red-lead putty. The joint between bolts and zinc should be made tight by means of red-lead putty.

Baskets, troughs or pans should be used to catch any disintegrated zinc. When a boiler, in which zinc is used, is opened for inspection, the zinc should be inspected, and if any oxidized zinc is found, the zinc should be scraped or renewed. When its thickness has been reduced to one-fourth inch, the zinc should be discarded and new zinc installed.

Attached is a digest of several references:

References.

1. Kent, 1900, page 720: Zincs are often used; their action is electrical, hydrogen going to the iron shell, and the oxygen to the zinc. It is supposed to prevent corrosion. In numerous cases the action has been harmful. Where scale consists of organic matter and lime, the action has been beneficial. With organic matter alone there is a tendency to make hard scale of zinc oxide and organic matter, enough so as to cause overheating.

2. Tulley, page 107: Zincs are used in boilers to prevent corrosion and to prevent scale. It is used to prevent corrosion mainly in marine boilers. It is used to prevent scale mainly in boilers fed with fresh water. A perfect metallic contact must be insured. Used for the prevention of scale, the theory is that particles of zinc wasted away mixed with solid matter in water and prevented adhering in the form of hard scale. Now generally believed that it acts electrically to prevent corrosion as well as scale. When water contains an excess of sulphates or chlorides over the carbonates, the acids of the former form soluble salts with the oxide of zinc. If the water contains mostly carbonates, there is no great amount of reaction. In externally fired boilers zinc should be used with caution, as it is liable to produce a heavy sludge leading to overheating. The evidence is very conflicting.

3. Helios, Heine Boiler Co., page 49: . . . in ocean service some sea water is apt to be fed, which sets up electrolytic action. Zinc plates are, there-

fore, placed in the drum to act as the electro-negative agent and prevent corrosion. In the Heine Marine Boiler, the U. S. Navy standard is used; that is, three-fourth sq. ft. exposed zinc for each 100 sq. ft. heating surface. A perfect electrical contact is insured and a pressed-steel basket is provided to catch the disintegrated zinc.

4. Christie, page 137: Dr. Kossman says that the use of zinc in boilers for the prevention of scale is useful in selenitic waters, but as against the carbonate of lime, carbonate of magnesium and carbonate of iron, it is of little value, the zinc quickly rendered porous, brittle and reduced to powder.

Dr. Moore says the most important results from the use of zinc is the protection of the plates from hydrochloric acid evolved from the chloride of magnesium in the sea water.

Dr. Corbigny says the galvanic action liberates hydrogen which lies close to the boiler metal, and prevents scale from adhering.

Dr. Worlington says zinc removes oxygen from the water; 13 pounds of zinc results in zinc oxide and will remove 3.2 pounds of oxygen from one ton of water.

5. "Marine Steam" says the use of zinc appears still a very important element of protection against corrosion due to air in feed water. It is recommended as a positive benefit suspended near entrance of feed, as it deflects to itself from the iron harmful action. Charles H. Haswell suggested the use of zinc in marine boilers thirty years before the English engineers recommended the same thing.

6. "Gill's Engine Room Chemistry", page 92: Pitting may be prevented by the introduction into the boiler of plates of zinc, which are dissolved in plate, being frequently done in marine boilers. They must be bolted onto projections from the boiler itself, making a good electrical contact. For new boilers allow one square foot of zinc to each fifty square feet of heating surface and later one-half this amount.

(W. E. S.)

Plantation Notes—Illustrated

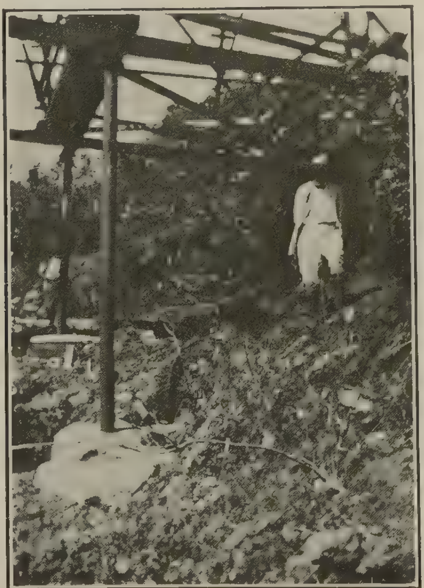
(Photographs by J. S. B. Pratt, Jr.)

A dry ditch at Oahu Sugar Company prevents tree roots from encroaching upon the cane.

These ditch gates at Oahu Sugar Company can be held at any desired height through the simple device of a hinge which engages bolt heads placed two inches apart.

An effective drain at a roadside, Pepeekeo, is made of half concrete pipe sections.

Difficulties in building flume trestle foundations to withstand freshets, have been met at the Hakalau Plantation Company by the use of a six-inch pipe standard set in concrete and reinforced with rail and cement. The arrow shows the high watermark of a recent torrent.

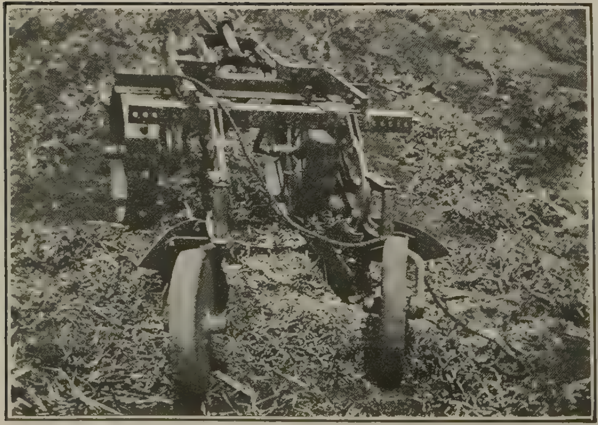


The flange at the top of the standard offers a means of bolting the woodwork to the foundation.

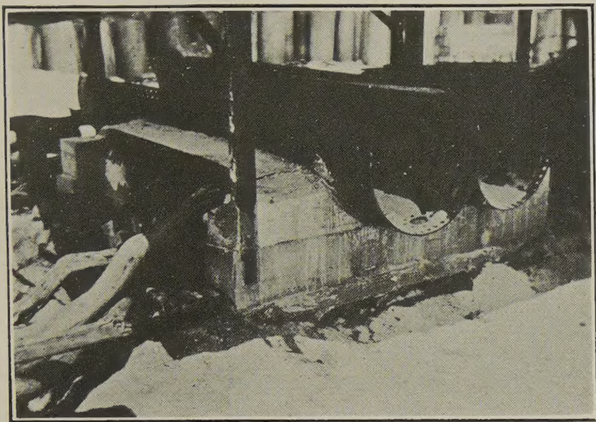
In looking down from the trestle the standard at the right is seen to have been slightly bent by the freshet, but the superstructure suffered no damage.

A tall observation pole denotes dry spots in Ewa's level fields, aiding in supervision of irrigation and in addition they are used in locating positions for firebreaks.

An instrument used at the Experiment Station for recording the hour-to-hour growth of cane leaves.

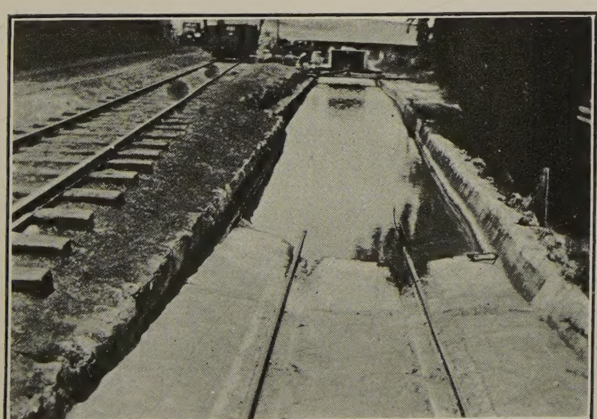


This type of off-barring plow is used on several Hawaii plantations.

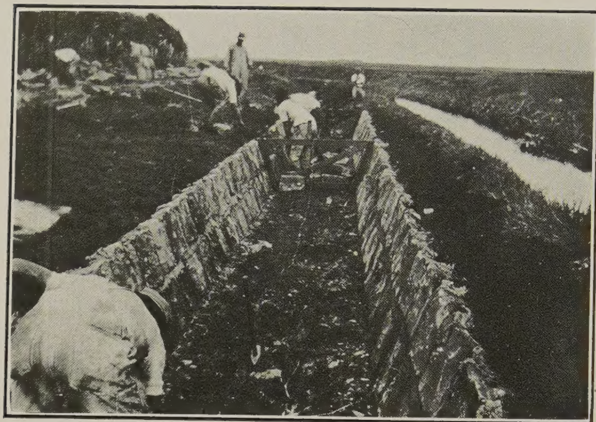


A convenient arrangement for drying sand for locomotives of the Oahu Sugar Company.

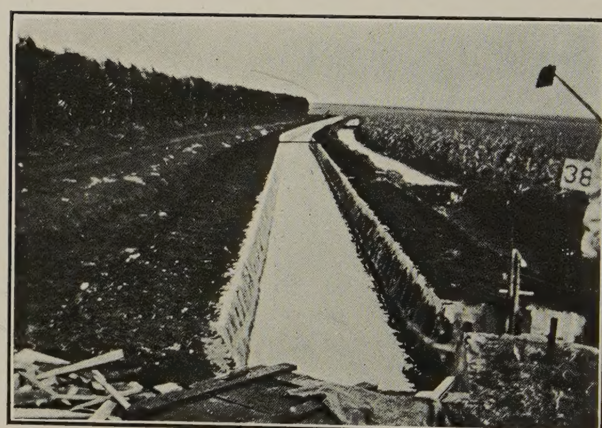
Mr. John Ross has used bright colored cannas effectively about the plantation buildings at Hakalau.



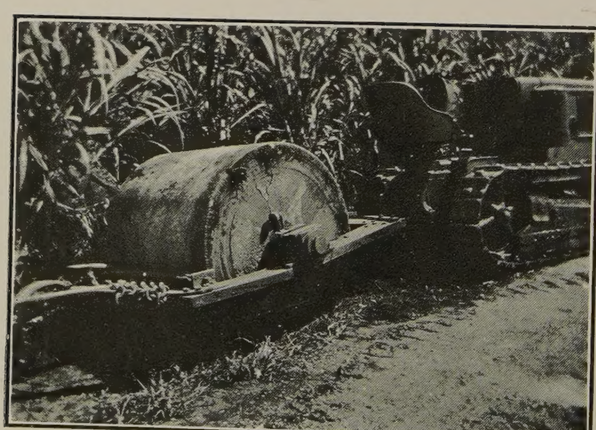
A seed soaking tank at Kahuku, which accommodates eight cars at a time.



A stone slab ditch under construction at Waipahu; the slabs are 1'x1'x4", and the bottom of the ditch is to be of 3" concrete.



The finished ditch.



A homemade road roller, Onomea, constructed from an old pulley by filling it with concrete after removing the flanges. The pulley was formerly used at the landing in shipping sugar.

Sugar Prices.

96° Centrifugals for the Period December 16, 1923, to March 15, 1924.

Date	Per Pound	Per Ton	Remarks
Dec. 18, 1923.....	7.28¢	$145.60	Cubas.
" 22..........	7.22	144.40	Cubas.
" 26..........	7.25	145.00	Cubas, 7.22, 7.28.
" 27..........	7.22	144.40	Cubas.
" 28..........	7.095	141.90	Cubas, 7.16, 7.03.
" 29..........	7.03	140.60	
Jan. 4, 1924.....	6.53	130.60	Cubas.
" 7..........	6.465	129.30	Cubas, 6.53, 6.40.
" 8..........	6.28	125.60	Cubas.
" 9..........	6.40	128.00	Cubas.
" 10..........	6.465	129.30	Cubas, 6.40, 6.53.
" 11..........	6.53	130.60	Cubas.
" 14..........	6.65	133.00	Cubas.
" 15..........	6.715	134.30	Cubas, 6.65, 6.78.
" 16..........	6.59	131.80	Cubas, 6.65, 6.53.
" 19..........	6.53	130.60	Cubas.
" 23..........	6.65	133.00	Cubas.
" 25..........	6.78	135.60	Cubas.
" 28..........	6.75	135.00	Cubas, 6.72, 6.78.
" 29..........	6.8433	136.87	Cubas, 6.78, 6.91; Porto Ricos, 6.84.
" 30..........	6.91	138.20	Porto Ricos.
Feb. 2..........	7.095	141.90	Cubas, 7.03; Porto Ricos, 7.16.
" 4..........	7.28	145.60	Cubas.
" 7..........	7.22	144.40	Cubas, 7.28, 7.22, 7.16.
" 13..........	7.41	148.20	Cubas, 7.41.
" 14..........	7.28	145.60	Cubas.
" 15..........	7.21	144.20	Cubas, 7.16, 7.28; Porto Ricos, 7.19.
" 16..........	7.22	144.40	Cubas.
" 18..........	7.16	143.20	Cubas.
" 20..........	7.09	141.80	Cubas.
" 25..........	7.41	148.20	Porto Ricos.
" 26..........	7.22	144.40	Cubas, 7.28, 7.16.
" 27..........	7.16	143.20	Porto Ricos.
Mar. 3..........	7.09	141.80	
" 4..........	7.16	143.20	Cubas.
" 7..........	7.09	141.80	Cubas.
" 10..........	7.16	143.20	Cubas.
" 11..........	7.09	141.80	Porto Ricos.
" 12..........	7.03	140.60	Cubas.